PB-215 654

WATER QUALITY CONTROL STUDY, BUMPING LAKE

Federal Water Pollution Control Administration
Portland, Oregon

January 1966

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

AF

PB 215 654

WATER QUALITY CONTROL STUDY

BUMPING LAKE ENLARGEMENT

Yakima River Basin, Washington

Reproduced by
NATIONAL TECHNICAL INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

JANUARY 1966

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

WATER QUALITY CONTROL STUDY

BUMPING LAKE ENLARGEMENT PROJECT
YAKIMA RIVER BASIN, WASHINGTON

An investigation has been made which defines present water quality and uses and which discloses a future need for storage for regulation of stream flow for water quality control. Future water requirements and quality projections are based on economic, demographic, and engineering studies.

Prepared at the Request of the U. S. Department of Interior,
Bureau of Reclamation, Upper Columbia River Development Office
Spokane, Washington

Details of illustrations in this document may be better studied on microfiche

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration, Pacific Northwest
Portland, Oregon

JANUARY 1966

TABLE OF CONTENTS

		Page No.
I.	INTRODUCTION	
	A. Request and Authority	I-1
	B. Purpose and Scope	I-1
	C. Acknowledgments	I-2
II.	SUMMARY OF FINDINGS AND CONCLUSIONS	
	A. Summary of Findings	II-1
	B. Conclusions	II-5
III.	PROJECT DESCRIPTION	
	A. Location	III-1
	B. Proposed Project	III-1
IV.	STUDY AREA DESCRIPTION	
	A. Boundaries	IV-1
	B. Physical Features	IV-2
	C. Climate	IV-3
V.	WATER RESOURCES OF THE STUDY AREA	
	A. Surface Water	V-1
	1. Existing Water Resource Development	V-1
	2. Stream Flow Frequency Analysis	V-5
	3. Quality of Water Available	V-5
	B. Ground Water	V-14
	1. Quantity	V-14
	2. Quality	V-14
VI.	THE ECONOMY	
	A. General	VI-1
	B. Present	VI-1
	1. Economic Activities	VI-1
	2. Population	VI-6
	C. Projected Economic Base & Population	VI-8
	1. Future Increases in Output and Employment of Major Industries	VI-8
	2. Future Labor Force	VI-12
	3. Estimated Future Population	VI-14

TABLE OF CONTENTS
(Continued)

		Page No.
VII.	WATER REQUIREMENTS--MUNICIPAL & INDUSTRIAL	
	A. Present Water Use	VII-1
	B. Forecast of Future Water Needs	VII-4
VIII.	WATER QUALITY CONTROL	
	A. Need for Control	VIII-1
	1. General	VIII-1
	2. Irrigation	VIII-1
	3. Municipal & Industrial Water Supply	VIII-1
	4. Fisheries	VIII-2
	5. Recreation & Riverside Uses	VIII-3
	B. Municipal, Industrial & Agricultural Pollution	VIII-4
	1. Municipal	VIII-4
	2. Industrial	VIII-6
	3. Agricultural	VIII-9
	C. Water Quality Criteria	VIII-10
	D. Flow Regulation	VIII-10
IX.	BENEFITS	IX-1
X.	BIBLIOGRAPHY	X-1
	APPENDIX	
	A. Water Quantity Data	A-1 to A-4
	B. Water Quality Data	B-1 to B-9

LIST OF TABLES

Table No.	Title	Page No.
V-1	Water Quality, Yakima River.	V-8
VI-1	Labor Force, by Industry Group, Yakima 3-County Area, April 1960	VI-2
VI-2	Comparative Distribution of Labor Force, By Industry Group, April 1960.	VI-3
VI-3	Acreage Harvested, By Principal Crops, Yakima 3-County Area, 1959	VI-5
VI-4	Population, By County and Incorporated Places, Yakima Valley Economic Area and 3-County Area.	VI-7
VI-5	Estimated Future Population of Yakima 3-County Area and Illustrative Distribution of Future Labor Force, 1960-2010.	VI-13
VI-6	Illustrative Projections of Future Population in Incorporated Places, Yakima Valley.	VI-16
VI-7	Projected Future Population, By Service Areas, Yakima Valley.	VI-17
VII-1	Water Supply Inventory	VII-2
VII-2	Present and Future Municipal and Industrial Needs, by Water Service Areas, Yakima River Basin	VII-5
VIII-1	Municipal Waste Loadings	VIII-6
VIII-2	Industrial Raw Waste Production, 1960.	VIII-8
VIII-3	Maximum Monthly Waste Loads.	VIII-11
VIII-4	Required Stream Flow Regimen for Quality Control Purposes, Yakima River Basin, Washington	VIII-16

LIST OF FIGURES [1]

Figure No.	Title	Page No.
V-1	Schematic Diagram, Yakima River Basin.	V-2
V-2	Map Depicting Storage, Diversions, and Irrigated Acreage, Yakima River Basin.	V-3
V-3	Yakima River Stream Flow, cfs, (Ten-Year Recurrence Interval)	V-6
V-4	Dissolved Solids Variations, Yakima River Basin. . . .	V-7
V-5	Coliform Bacteria Counts, Yakima River	V-9
V-6	Water Temperature Profiles, August, 1955, Yakima River	V-11
V-7	Dissolved Oxygen, Per Cent Saturation, Yakima River Basin	V-13
VII-1	Municipal and Industrial Water Demand, Yakima River Basin	VII-6
VIII-1	Municipal and Industrial Raw Waste Production, Yakima River Basin	VIII-7
VIII-2	Present and Projected Dissolved Oxygen Profiles, Yakima River Basin	VIII-14
VIII-3	Additional Flow Required for Water Quality Control .	VIII-15
---	Location Map	Back Cover

1/ Figures incorporated in this report were finalized in August 1965 and title blocks show the reporting agency's name as "Public Health Service". Effective January 1, 1966, this organization's name was changed to "Federal Water Pollution Control Administration".

I. INTRODUCTION

A. Request and Authority

The request for this report was made by the U. S. Bureau of Reclamation by letter dated June 20, 1962. Authority for the investigation and report is the "Federal Water Pollution Control Act", as amended (33 U.S.C. 466b(b)).

B. Purpose and Scope

The investigation on which this report is based was conducted for the purpose of advising the Bureau of Reclamation on the need for and value of storage in Bumping Lake Enlargement, Yakima River Basin, for water quality control. To accomplish this, all available data on water uses, waste sources, and water quality were examined, evaluated, and projected. Field data collected by the Public Health Service and Washington State Pollution Control Commission in 1961 and 1962 aided the evaluations.

The area covered in the report includes all of the Yakima River Basin drainage and is defined demographically by areas within Benton, Kittitas, and Yakima Counties.

Evaluations include projected conditions to the year 2010, with an interim date of 1985. An economic base study was prepared for this purpose and is summarized in the report.

The findings of the report are based on comprehensive studies being conducted in this region by the Federal Water Pollution Control Administration.

C. Acknowledgments

Information for this report was provided by officials of the Cities of Yakima, Ellensburg, Sunnyside, Cle Elum, and Prosser; the Nob Hill Water Company; the Yakima Chamber of Commerce; the Washington State Department of Health; the Washington State Pollution Control Commission; the U. S. Bureau of Reclamation; the U. S. Bureau of Indian Affairs; the U. S. Geological Survey; the engineering firm of Gray and Osborne of Yakima; the engineering firm of Cornell, Howland, Hayes and Merryfield of Corvallis, Oregon; and the Engineering Department of the University of Washington. The cooperation of persons within these organizations is gratefully acknowledged. The assistance of organizations and individuals attending the public meeting held by the Public Health Service, in Yakima, April 27, 1965, is also acknowledged.

II. SUMMARY OF FINDINGS AND CONCLUSIONS

A. Summary of Findings

1. The Bumping Lake Enlargement Project proposed by the Bureau of Reclamation consists of a 223-foot high dam located on Bumping River about 4,500 feet downstream from the present Bumping Lake Dam (see Location Map, back cover). It is proposed with this project to increase the storage capacity of Bumping Lake from 33,700 acre-feet to about 458,000 acre-feet. The enlargement would include space for several years of carry-over storage. Management of the reservoir would be coordinated with existing water resource development in the basin to serve needs for supplemental irrigation, flood control, municipal and industrial water supply, fish and wildlife, recreation, and water quality control.

2. The study area covered in this report is the entire Yakima River drainage basin which is comprised of Yakima, Kittitas, and Benton Counties. Subareas examined in the study are the Cle Elum-Roslyn area, Ellensburg-Kittitas area, Naches-Yakima-Moxee City area, Wapato-Toppenish area, Sunnyside-Grandview area, and Prosser-Benton City area.

3. The drainage area of Yakima Basin is about 6,000 square miles. Existing reservoirs in the basin are Keechelus, Kachess, Cle Elum, Bumping Lake, Rimrock (Tieton), Clear Lake, and Wenas Creek. About 1,072,000 acre-feet of usable storage capacity has been developed in these reservoirs.

4. The average annual runoff of the basin, as measured at the lower-most gaging station on the river (drainage area 5,600 square miles), is 2,660,000 acre-feet. The one-in-ten year low mean annual runoff to the Yakima River at several points from upper to lower basin are:

	cfs	acre-feet
Cle Elum	1,100	800,000
Umtanum	1,600	1,160,000
Above Parker	3,000	2,170,000
Below Parker (Sunnyside Diversion)	680	495,000
Kiona	1,700	1,230,000

Minimum flows in the main stem of the river occur below Parker (Sunnyside Diversion Dam) during the irrigation season. The minimum monthly average flow recorded at this location is about 100 cfs.

5. The economic base of the Yakima Valley is agriculture. Water resource development is oriented principally toward this base.

6. The 1960 population of the study area was 177,000. About 62 per cent of the population resided in urban areas and 38 per cent resided in unincorporated towns and rural areas. There is potential for considerable population growth. The projected populations for 1985 and 2010 are 239,000 and 326,000, respectively.

7. Water use for municipal and domestic purposes in the study area in 1960 was about 36 million gallons per day (MGD), and for industrial use about 9 MGD. Approximately 70 per cent of the water used for these purposes is obtained from underground sources. Based on future population and industrial growth expected in the area, the potential demand for water for these purposes by the years 1985 and 2010 is projected to be 74 MGD and 122 MGD, respectively.

The industrial demand has been increasing at a slightly greater rate than the municipal demand and is expected to continue this trend.

8. Surface waters, in addition to being used for municipal and industrial supply, are used for irrigation, fish and game propagation, stock watering, recreation, hydroelectric power, and disposal of municipal and industrial wastes. Stream waters in the lower basin areas receive and at times consist almost entirely of return flows and drainage water from irrigated lands.

9. The mineral quality of surface waters in upper Yakima River areas is excellent. Waters in the lower reaches of the river are significantly higher in mineral content but are suitable for all uses, including municipal and industrial water supply. Biochemical oxygen demand (BOD) received in the river from waste and land drainage sources is adequately assimilated in most stream sections without detriment to the dissolved oxygen (DO) requirements of fish and other aquatic life. Survey data show that the critical DO zone occurs in lower reaches of the river and is most pronounced under early morning conditions during summer and early fall months.

10. The City of Yakima has completed facilities for secondary waste treatment with provisions for disinfecting municipal wastes on a year-round basis. Industrial wastes at Yakima will receive similar treatment during winter months. During summer months, control of this waste is accomplished by sprinkler irrigation. Lagoons are provided to collect any subsequent runoff. The goal of the Washington State

Pollution Control Commission for Yakima River Basin is for ultimate year-round achievement of greater than 85 per cent BOD removal at all sources by means of a combination of these control methods.

11. Average daily municipal waste production in the study area in 1960 (before treatment) was about 222,000 population equivalents (PE). With present treatment, it is estimated that about 33,000 PE of this waste is received in stream waters of the basin. Industrial waste production in the study area in 1960 averaged about 312,000 PE. Existing disposal practices are believed capable of accomplishing an over-all average reduction of these wastes to about 45,000 PE per day. According to present information, about 90 per cent of the municipal and industrial waste in the study area is produced along the lower Yakima River within and below the Naches-Yakima-Moxee City service area.

12. Survey data indicate that land drainage and irrigation return flows add an average of about . milligrams per liter (mg/l) of BOD to Yakima River waters. Farm animals, having an estimated waste potential of about 1,300,000 PE, decomposable vegetative matter, and dead and dying aquatic organisms contribute significantly to the oxygen demand on the river.

13. There is evidence that irrigation return flows cause increased water temperatures in the lower Yakima River where major return flows occur. Between Parker and Kiona, water temperatures rise rapidly to attain values of 70 to 80 degrees Fahrenheit (^{o}F.).

B. Conclusions

1. The future economic growth of Yakima River Basin will be dependent to a large extent on a continuation of water resource development for agricultural purposes. The proposed enlargement of Bumping Lake is one of several efforts being made to further this development.

2. Diversions of stream flow for irrigation (about 2.5 million acre-feet annually) and return flows resulting from this use of water are the major factors affecting water quality in the Yakima River. Increased stream temperatures, excessive aquatic growths, high turbidity, and excessive sediment loads are some of the effects resulting from this practice. Municipal and industrial waste effluents, averaging about 80,000 PE per day, and domestic farm animal wastes, estimated at about 65,000 PE per day, have compounded these effects by contributing bacterial organisms, nutrients, and oxygen-demanding materials to the river.

3. Utilization of the Yakima River for anadromous and resident game fish production and recreation have been curtailed due to low stream flows and reduced stream quality. Stream waters, particularly in the lower 30 to 40 miles of the river, are unfit for water-contact activities because of bacterial contamination (>1,000 coliforms per 100 ml) and are undesirable as a source of municipal and industrial water supply. Fluctuations in temperature, algal growths, turbidity, and occurrences of slimes would be expected to create operational difficulties in the treatment of these waters were they to be used for municipal and industrial supply.

4. Additional irrigation development and increased population and industrial growth along the Yakima River is expected to cause a further reduction in water quality below Sunnyside Diversion Dam. Oxygen-demanding wastes, even after a reasonable level of treatment has been applied, are expected to exert greater demands on the DO resource of the lower river. Stream temperatures (already relatively high, 70-80 ^{o}F.), algal growths, turbidity, and other factors characteristic of the quality of waters in this reach may also increase as future economic expansion progresses.

5. Continuous expenditures for waste treatment facilities will be needed to keep pace with population growth and industrial expansion in the Yakima Basin. Expenditures for municipal waste treatment alone between the years 1957 and 1963, for example, were about $2,800,000. Assuming that future updating of waste treatment facilities and practices will accomplish BOD removal of at least 85 per cent, the daily average waste loads expected to remain after this treatment, together with uncontrolled loads from urban and rural runoff, are projected to more than triple present loads or increase to about 275,000 PE by the year 2010. About 90 per cent of the projected future load is expected to be received in the lower 30-40 mile reach of the Yakima River where large diversions for irrigation take place and where stream flows at times consist entirely of irrigation return flow.

6. The future control of water quality in the Yakima River will require (1) adequate waste treatment or other methods of controlling waste at the source, (2) continuous disinfection of treatment plant effluents, (3) assured quantities of stream flow to maintain a minimum DO level of at least 5 mg/l in the critical zone of the river below Sunnyside Diversion Dam, (4) channelization of the river to reduce stream width for temperature reduction, (5) controlled surface and sub-surface drainage to reduce nutrient and temperature effects, and (6) controlled use of chemicals to minimize pesticide concentrations in the stream. If DO is permitted to fall below 5 mg/l and stream temperatures cannot be reduced to at least 70 ^{o}F., the free passage of anadromous fish species to and from upper basin spawning areas will be further jeopardized and possibilities of upgrading recreational opportunities, aesthetic values, and other assets associated with an attractive stream would be further reduced.

7. Field observations and computer studies incorporating oxygen-balance techniques, show that present waste loads and loads projected for 1985 can be assimilated in the minimum one-in-ten year low summer and fall flow of the river (about 100 cfs) without reducing DO below 5 mg/l in the critical zone (low point at Prosser). According to these computations, however, the projected 2010 load would reduce the average monthly level of DO to below 5 mg/l or to about 4 mg/l during summer and fall months one year out of ten. DO levels down to 3 mg/l could at times be expected to occur due to diurnal fluctuation in waste loads.

8. It is estimated that by the year 2010 an average flow of 280 cfs, as measured at the Parker gaging station (during July, August, September, and October), will be required to control DO at 5 mg/l in the Yakima River below Sunnyside Diversion Dam. In order to maintain this control, there will be a need beginning about the year 1995 for an annual draft-on-storage* of 50,000 acre-feet from Bumping Lake Reservoir. Releases would be required at such time and in such amounts as may be dictated by seasonal variations in waste loadings and DO conditions downstream. Stream temperatures in the lower river would not be affected at this level of release or at higher releases even if cooler water from lower levels of the reservoir were available and could be withdrawn. Temperature studies, although incomplete, indicate that the only feasible means of reducing summer stream temperature between Parker and Kiona would primarily be to reduce stream width through channelization between Parker and Kiona and, secondly, to reduce surface return flows.

9. Storage releases from Bumping Lake Reservoir for water quality control below Sunnyside Diversion Dam (Parker-to-Kiona reach of Yakima River) would benefit a potential population of 300,000 persons residing along 20-30 miles of the river and would improve fishing and other recreational uses of the river. The fishing effort, for example, is estimated at about 835,000 angler days per year at the present time and the potential or full re-establishment of the fishery is valued at about $4,000,000 annually.

---

*Annual draft-on-storage is the sum of incremental excesses of needed releases over inflows during a climatic year (April to April).

10. The beneficiaries of water quality maintenance in Yakima River Basin are identifiable in general terms, many of which, however, are not directly measurable in monetary terms. The minimum value of the benefits assignable to Bumping Lake Reservoir for quality control is considered, therefore, to be at least equal to the cost of the most likely alternative means of providing the same level of water quality in the absence of the project. After considering such alternatives as the transmission of wastes downstream, transmission of wastes out of the basin, additional land disposal of wastes, and single-purpose releases from storage, it was determined that single-purpose releases from storage is the only means whereby equivalent control could be achieved, particularly in view of needs to control runoff and land drainage wastes.

11. The minimum value of the benefits assignable to an annual draft-on-storage of 50,000 acre-feet in Bumping Lake Reservoir is estimated to be $150,000 or $3.00 per acre-foot. This value is based on the capital cost of a single-purpose reservoir constructed at the least-cost most-likely site on Little Naches River above the City of Yakima amortized over a 100-year project life, with an annual operation and maintenance (O&M) expense of $13,000, a discount period of 20 years (assumed project completion in 1975), and interest at 3.125 per cent.

12. It is not known whether full re-establishment of the fishery potential of Yakima River Basin could be achieved in view of the large appropriation of waters for irrigation. The fishery potential would be preserved in part at least by releases from storage for maintenance of water quality.

13. The benefits derived from water quality maintenance in the Yakima River are both tangible and intangible and are widespread both in area and type of beneficiary. While the benefits discussed above apply primarily to the Yakima River, additional widespread benefits in terms of improved water quality downstream along the Columbia River would also be realized. These latter benefits, however, are not possible to identify at this time.

14. Future municipal and industrial water requirements in the study area, particularly in the Naches-Yakima-Moxee City service area, will exceed available supplies within the next 50 years. It is understood, however, that local communities and/or industries have taken no action toward retaining water supply storage in the proposed reservoir. Because surface waters are nearly fully allocated at the present time, it may be desirable to give early consideration to storage for this purpose in any future water resource development proposals in the basin. It is expected that ground water will continue to supply the future needs of the smaller municipalities and industries in the basin.

III. PROJECT DESCRIPTION

A. Location

Bumping Lake Dam and Reservoir is located near the headwaters of Bumping River, a tributary of the Naches River, which joins the Yakima River near the City of Yakima (see Location Map, back cover).

As proposed by the U. S. Bureau of Reclamation, the Bumping Lake Enlargement Project will increase storage from 33,700 to 458,000 acre-feet by means of a 223-foot high dam about 4,500 feet downstream from the existing dam. The drainage area above the proposed site is 69 square miles and the average annual runoff is 210,000 acre-feet. Space for several years of carry-over storage is being planned in the project to provide supplemental water during dry years.

Water at this elevation is generally of good chemical, physical, and biological quality. The area is relatively inaccessible during the winter months and is used primarily for fishing in summer months. Annual fluctuations in water-surface elevation will not be as great in the enlarged reservoir as in other lakes of the system due to the hold-over storage characteristics. In dry years, however, considerable fluctuation would occur.

B. Proposed Project

The operation of Bumping Lake Enlargement Project would be coordinated with existing storage development in the Yakima River system to allow more freedom in serving needs for irrigation, flood control, and needs for improved flows for fishery use. Fishway facilities at some of the existing dams would also be provided.

IV. STUDY AREA DESCRIPTION

A. Boundaries

Because the proposed project would affect all parts of the basin, the entire drainage area of the Yakima River was selected for study. The area, which encompasses about 6,000 square miles, is located in South-Central Washington on the eastern slope of the Cascade Mountains and extends from Keechelus Reservoir to Richland, a distance of about 215 miles (see Location Map, back cover). The basin is bounded on the northeast by the Wenatchee Range, on the east by Rattlesnake Hills, and on the south by Horse Heaven Hills. Upthrust ridges lying in an east-west direction across the basin divide it below the City of Ellensburg, above and below the City of Yakima, and below Prosser. The area is comprised of Yakima, Kittitas, and Benton Counties.

In terms of physical characteristics and economic development, the basin lends itself to division into six distinct water-service areas: (1) Cle Elum-Roslyn; (2) Ellensburg-Kittitas; (3) Naches-Yakima-Moxee City; (4) Wapato-Toppenish; (5) Sunnyside-Grandview; and (6) Prosser-Benton City.

The economic base of the Cle Elum-Roslyn area is predominantly forest land and light agriculture, along with some coal mining. The Ellensburg-Kittitas area is almost entirely pasture land for cattle raising. The Naches-Yakima-Moxee City area produces fruit, vegetables, hops, and other related products which are processed locally.

Activities in the Wapato-Toppenish area include sugar refining and fruit and vegetable processing. In the Sunnyside-Grandview area, processing of fruit and vegetables predominates. The Prosser-Benton City area is in the narrower section of the basin and contains vineyards, producing grapes which are processed in the Prosser area.

B. Physical Features

Variations in the terrain of the Yakima River Basin range from rugged forest lands in the Cascade Mountains and Wenatchee Range to relatively level fertile valleys in the lowlands of the basin formed by the east-west ridges. The ridges, Rattlesnake Hills and Horse Heaven Hills, are basalt outcroppings practically devoid of vegetation except for early spring grasses. Altitudes in the basin range from 8,200 feet in the Cascades to 320 feet at the mouth of the river. Glaciers on the western edge of the basin at elevations above 7,000 feet aid in maintaining runoff in the mountain streams during the late irrigation season. Between the City of Ellensburg and Selah, the river flows through a narrow steep-walled canyon for about 25 miles. Just above the confluence of the Naches River, the Yakima River flows through a narrow gap (Selah Gap). About 10 miles downstream, it is joined by Ahtanum Creek and flows through Union Gap into the broad portion of the valley, which extends to Prosser, where the canyon again narrows for several miles. The valley areas from Prosser to the mouth are small, narrow patches adjacent to the river.

C. Climate

The climate is variable. In the upper Cascades, annual precipitation may reach over 100 inches, whereas in the valley floor it may be as low as 6 inches. This variation is the result of orographic rainfall from the Pacific Ocean (i.e., the high mountains literally wring out the moisture as it passes over, and the valley is left in the rain shadow of the mountains). Much of the precipitation occurs as snow in the upper reaches. Most of the year in the valley areas the climate is relatively mild, but extreme temperatures of minus 5 degrees Fahrenheit and over 100 degrees Fahrenheit do occur. Generally, frost-free days may be expected from mid-May to mid-September. The use of smudge pots and other devices to alleviate effects of frost are used to protect orchard crops from unusually low spring temperatures.

V. WATER RESOURCES OF THE STUDY AREA

A. Surface Water

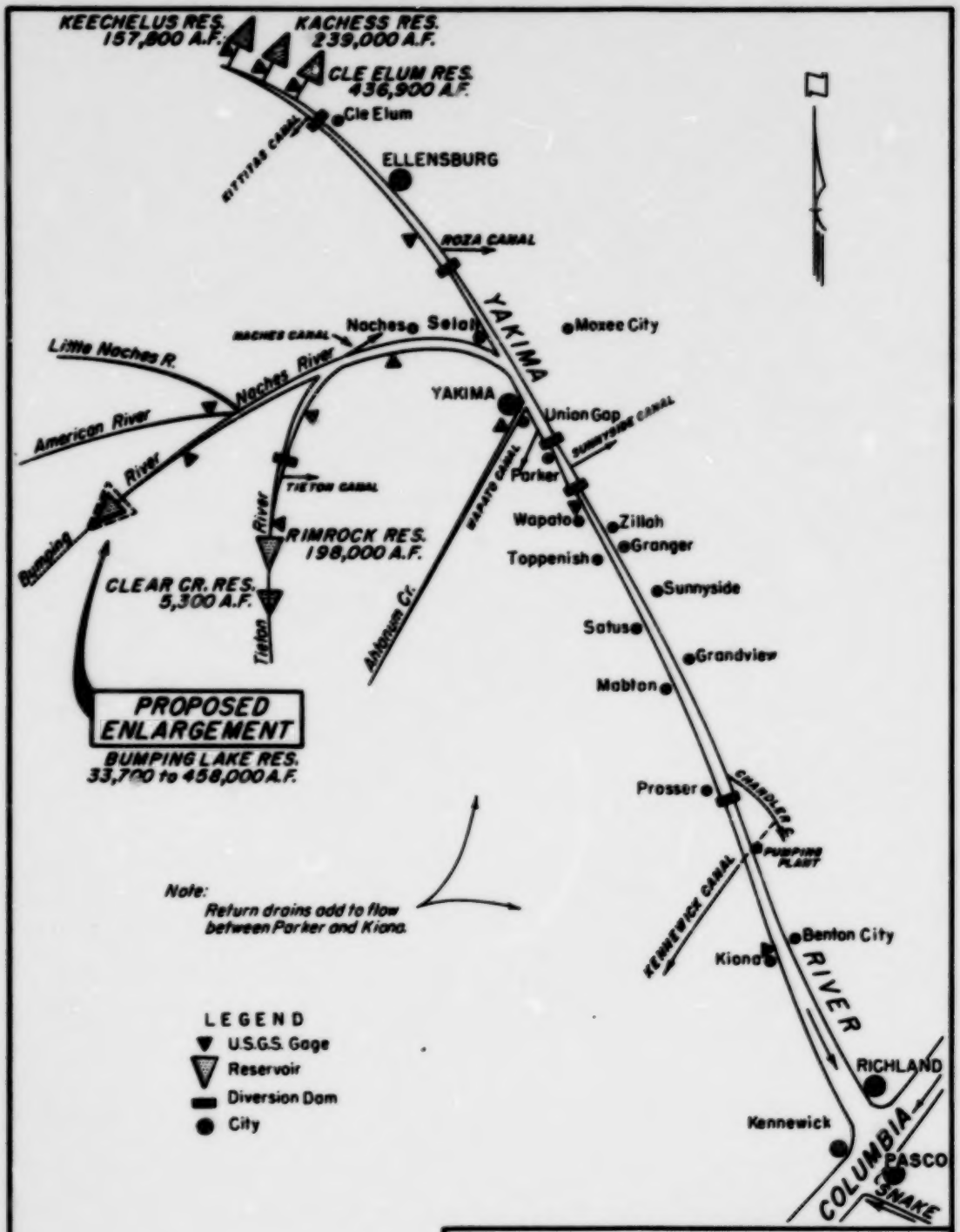
1. Existing Water Resource Development

Lands in Yakima River Basin have been irrigated since before the turn of the century. At present, six major reservoirs store water for use on about 450,000 irrigable acres (see FIGURE V-1, Schematic Diagram). These reservoirs have a combined usable capacity of about 1,072,000 acre-feet, as shown below.

RESERVOIR	ACRE-FEET
Keechelus	157,800
Kachess	239,000
Cle Elum	436,900
Bumping Lake	33,700
Rimrock (Tieton)	198,000
Clear Lake	5,300
Wenas Creek	1,300

In addition to the proposed Bumping Lake Enlargement, further development of storage may be provided in the proposed Bureau of Indian Affair's Toppenish-Simcoe Project on Simcoe Creek (37,000 acre-feet) and there are possibilities for storage on Teanaway River, Little Naches River, Ahtanum Creek, Cle Elum Reservoir, and the main Yakima River below Ellensburg. FIGURE V-2 shows the location of major reservoirs and streams on which additional storage development is possible.

All waters in Yakima River Basin, except for some surplus flow during winter months, are fully appropriated. The following list



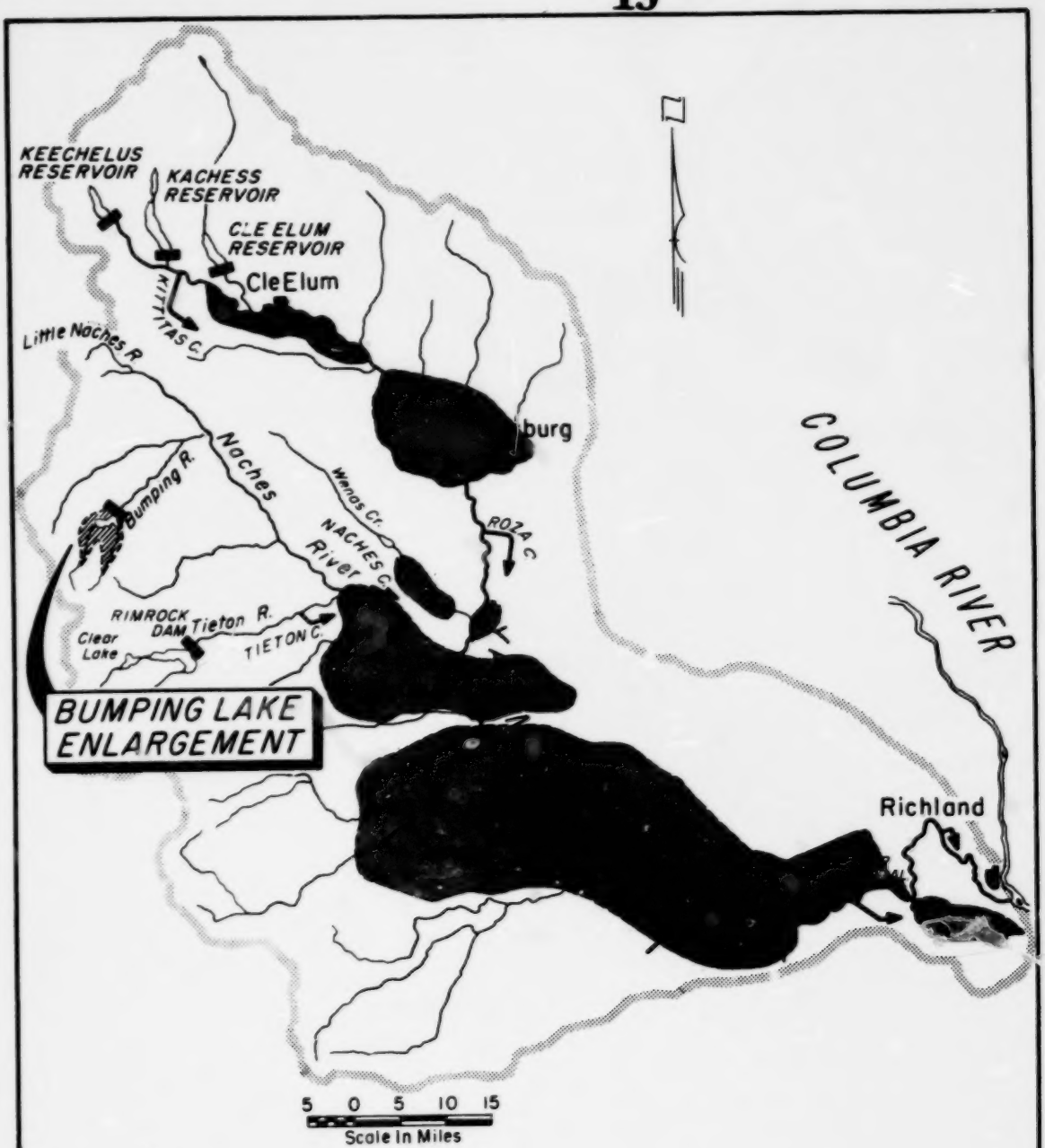
WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

SCHEMATIC DIAGRAM

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION IX (DATE: 8/65) PORTLAND, OREGON

FIGURE V-1



LEGEND

- Irrigated Acreage
- Storage
- Diversions or Drainages

WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

STORAGE, DIVERSIONS and IRRIGATED ACREAGE

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION IX (DATE: 8/65) PORTLAND, OREGON

summarizes water rights in the basin and shows that much of the water would be reused several times if all rights were exercised simultaneously during summer months:

MONTH	WATER RIGHTS* cfs	MEAN FLOW AT KIONA (1941 - 1962) cfs
January	630	3,499
February	630	3,956
March	690	4,122
April	4,360	4,800
May	6,740	6,080
June	7,360	5,971
July	7,390	2,206
August	7,220	1,673
September	5,070	1,814
October	2,860	2,528
November	630	3,202
December	630	4,180

With existing storage, all water rights can be met during normal water years. However, during dry years, storage is inadequate and the available water is prorated according to the priorities established by court action as set forth in the Consent Decree of 1945. Records show that flows below some diversion points, particularly those below Sunnyside and Prosser, fall to less than 50 cfs for several days at a time.

Records for Parker (see APPENDIX A) show that diversions at Sunnyside have depleted the stream to a minimum day of 14.5 cfs and a minimum month of 107 cfs. These minimum flows can occur in any of the

---

* Data obtained from Bureau of Reclamation summaries.

months from July through October, depending on climatic conditions. Return flows exert substantial recovery to a minimum day of 730 cfs and a minimum month of 1,216 cfs at Kiona.

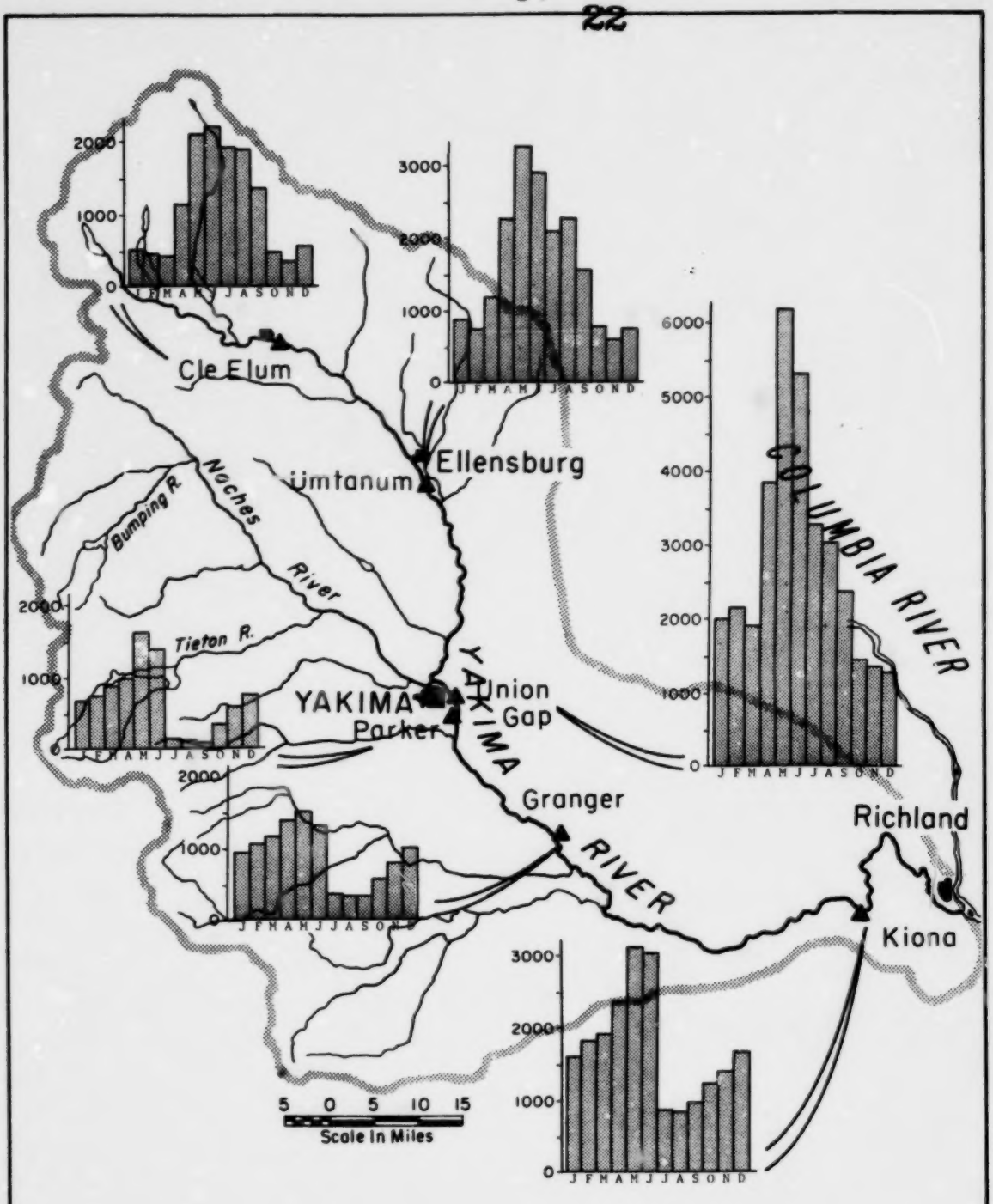
2. Stream Flow Frequency Analysis

Historical records show that relatively consistent regulation has occurred in the basin since 1941, making it possible with minor adjustments at several locations to develop low-flow frequency probabilities by standard analytic procedures. A low-flow frequency analysis was performed using the mean monthly flows of record for the twenty-two years from 1941 through 1962. Mean monthly low flows with recurrence intervals of 2, 5, and 10 years were developed from records at Cle Elum, Umtanum, Parker, and Kiona. These flows are presented in APPENDIX A (Tables 3, 4, and 5).

FIGURE V-3 shows the effect of diversions at Parker and the increased flow contributed by return flows between Parker and Kiona. The net loss of water shown is believed lost through evapo-transpiration processes and percolation to ground water aquifers. FIGURE V-3 also points out the April-May-June flood peak or water which would be available for additional storage development.

3. Quality of Water Available

Yakima River water is reduced in quality as it flows downstream. TABLE V-1 and APPENDIX B are typical examples of water quality at several locations along the river. FIGURE V-4 typifies dissolved solids at various stream flows.



WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

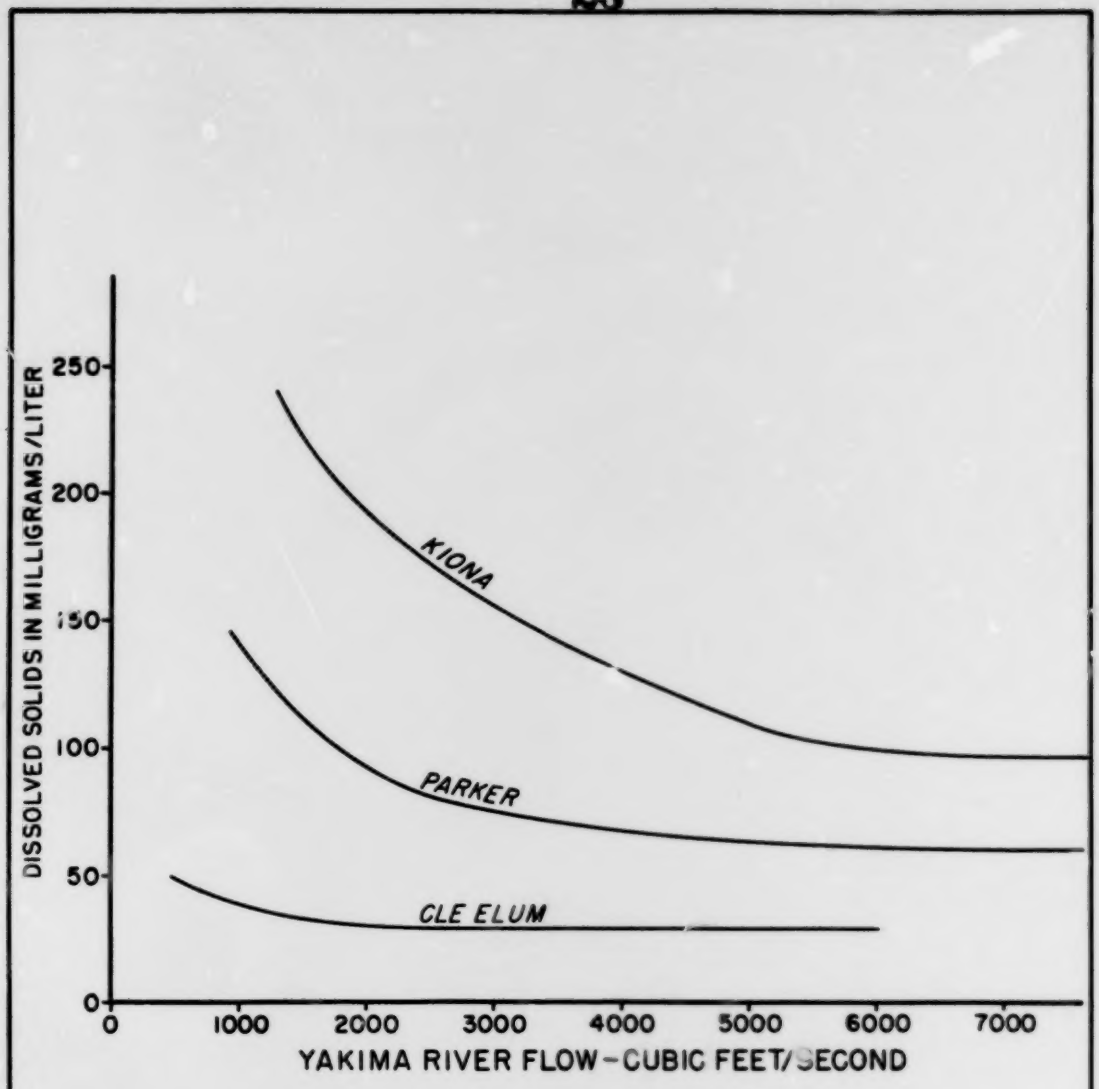
YAKIMA RIVER STREAMFLOW, CFS
(Ten-Year Recurrence Interval)

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION IX (DATE: 8/65) PORTLAND, OREGON

Reproduced from best available copy.

FIGURE V-3



Note:
Data from U.S.G.S., Quality of Surface Waters of the United States 1965 - 61

WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

DISSOLVED SOLIDS VARIATIONS

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION IX (DATE: 8/65) PORTLAND, OREGON

FIGURE V-4

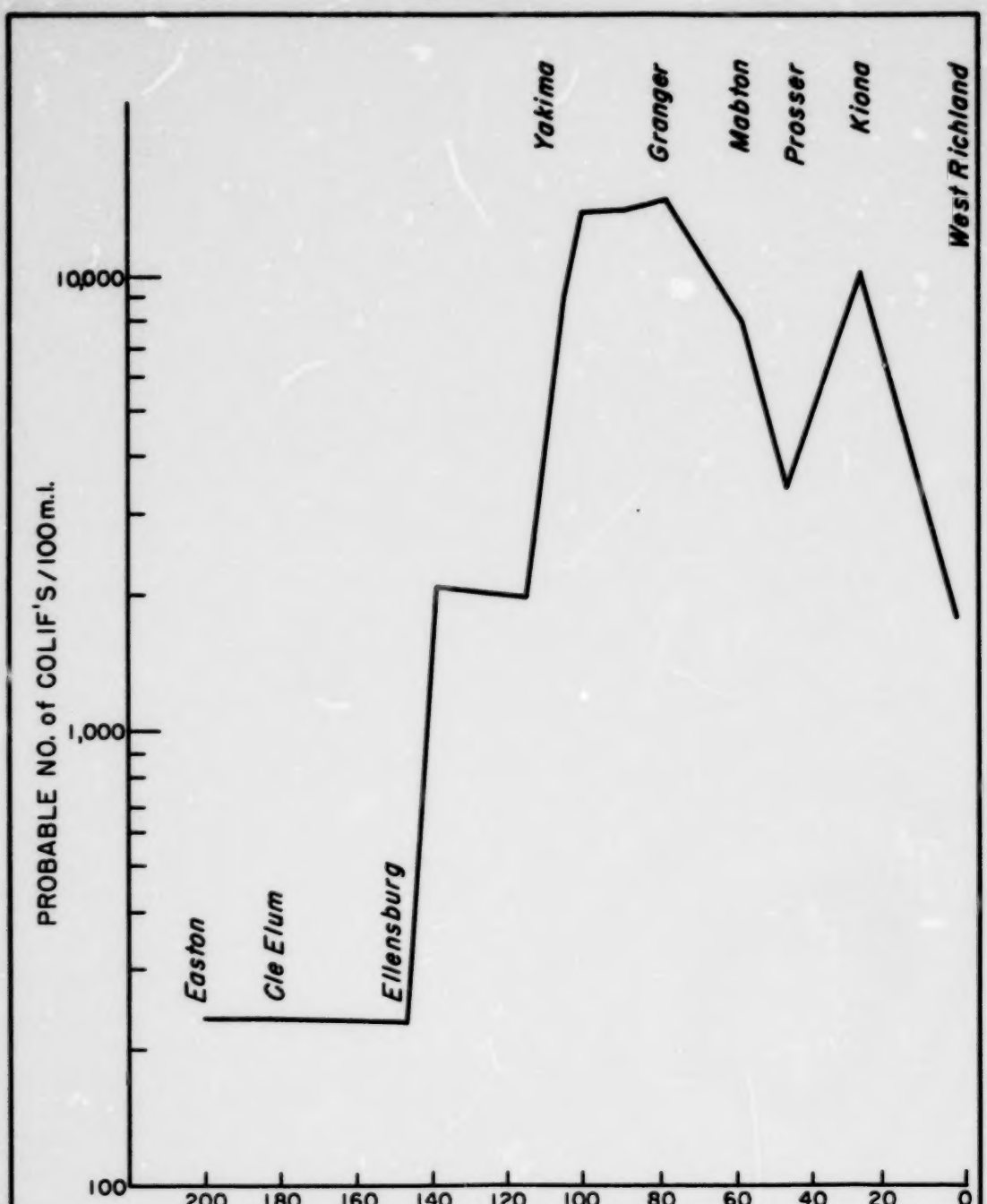
The phosphate and nitrate concentrations shown in TABLE V-1 for lower reaches are in excess of threshold limits for stimulation of nuisance aquatic organisms. The overall mineral quality, however, is adequate for municipal and most industrial water uses.

TABLE V-1
WATER QUALITY - YAKIMA RIVER

Constituent	Concentration, mg/l Cle Elum	Parker	Kiona
SiO_2	6.3	15.0	39.0
Fe	0.05	0.02	0.01
Ca	5.0	12.0	32.0
Mg	1.7	3.5	9.9
Na	0.8	6.4	20.0
K	0.4	1.3	3.6
PO_4	0.00	0.08	0.31
SO_4	1.1	5.0	22.0
Cl	0.5	2.5	7.5
NO_3	0.1	0.4	2.7
HCO_3	26	64	165
TDS	28	86	200
Total Hardness as $CaCO_3$	21	48	65
Total Alkalinity as $CaCO_3$	22	55	140

Examples of the bacterial quality of Yakima River water are given in FIGURE V-5. Between Yakima and Granger, where maximum bacterial (coliform) counts occur, nearly all of the flow is diverted to the irrigation canals on both sides of the river.

Results of several sampling runs conducted by the Public Health Service in the summer of 1962 are shown in APPENDIX B (Table 2).



WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

COLIFORM BACTERIA COUNTS
Sept. 19-20, 1962

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

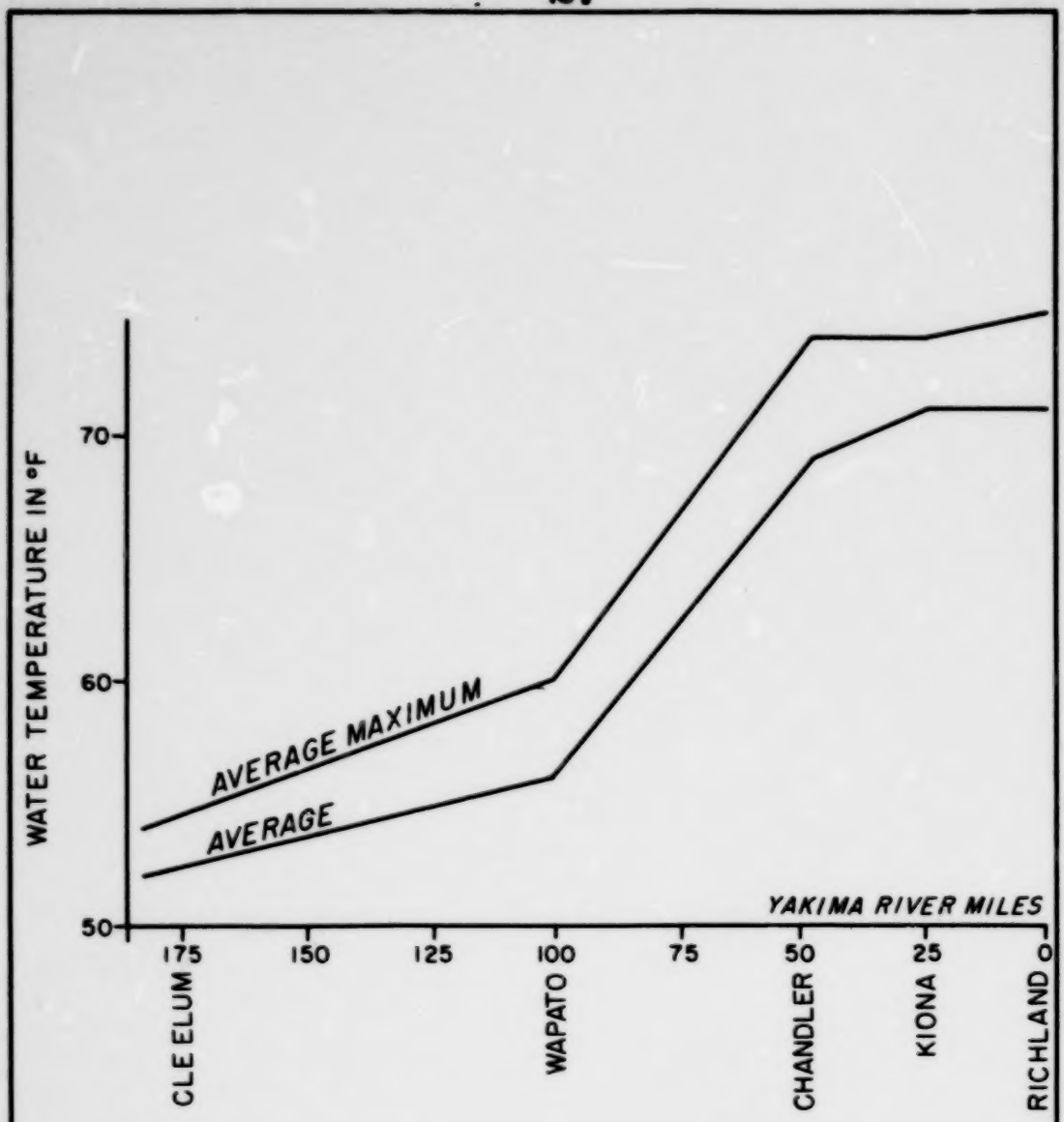
REGION IX (DATE: 8/68) PORTLAND, OREGON

FIGURE V-5

According to these runs, the fecal coliform and fecal streptococci counts follow the same pattern and together show that much of the pollution is from human wastes. The bacterial quality of the Yakima River below Yakima is unsatisfactory for swimming and as a raw water supply for municipal and food processing purposes. All cities are now chlorinating effluents or will be by the summer of 1965 at the direction of the Washington State Pollution Control Commission.

Heavy growths of plankton and higher life forms are found in the Yakima River from Roza Diversion Dam to the mouth of the river (see APPENDIX B, Table 3). Photosynthetic and respirational activities of these organisms are believed responsible for the diurnal fluctuation in DO (65 to 110 per cent of saturation), pH, alkalinity, CO_2, etc., in the Yakima River, indicated by these data.

Large releases of cool water from storage, combined with inflow from the principal unregulated streams, result in relatively low summer temperatures in the upper Yakima River downstream to Parker. Average values are less than 60 degrees Fahrenheit. Between Parker and Kiona, water temperatures rise rapidly to attain values of 70 to 80 degrees Fahrenheit. Temperatures below Kiona remain essentially unchanged to the river mouth (see FIGURE V-6 and APPENDIX B, Tables 4a, 4b, and 4c). Water temperatures between Parker and Kiona rise rapidly even at relatively high discharges (300 to 3,000 cfs at Parker). Low stream velocities in wide stream sections appear to cause this rise.



WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

WATER TEMPATURE PROFILES
August 1955

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION IX (DATE: 8/65) PORTLAND, OREGON

FIGURE V-6

DO in Yakima River exhibits considerable diurnal fluctuation and is lowest in the vicinity of Granger (6.0 to 6.5 mg/1). The DO pattern shown in FIGURE V-7 indicates that the effect of photosynthetic organisms govern the DO regimen of the river.

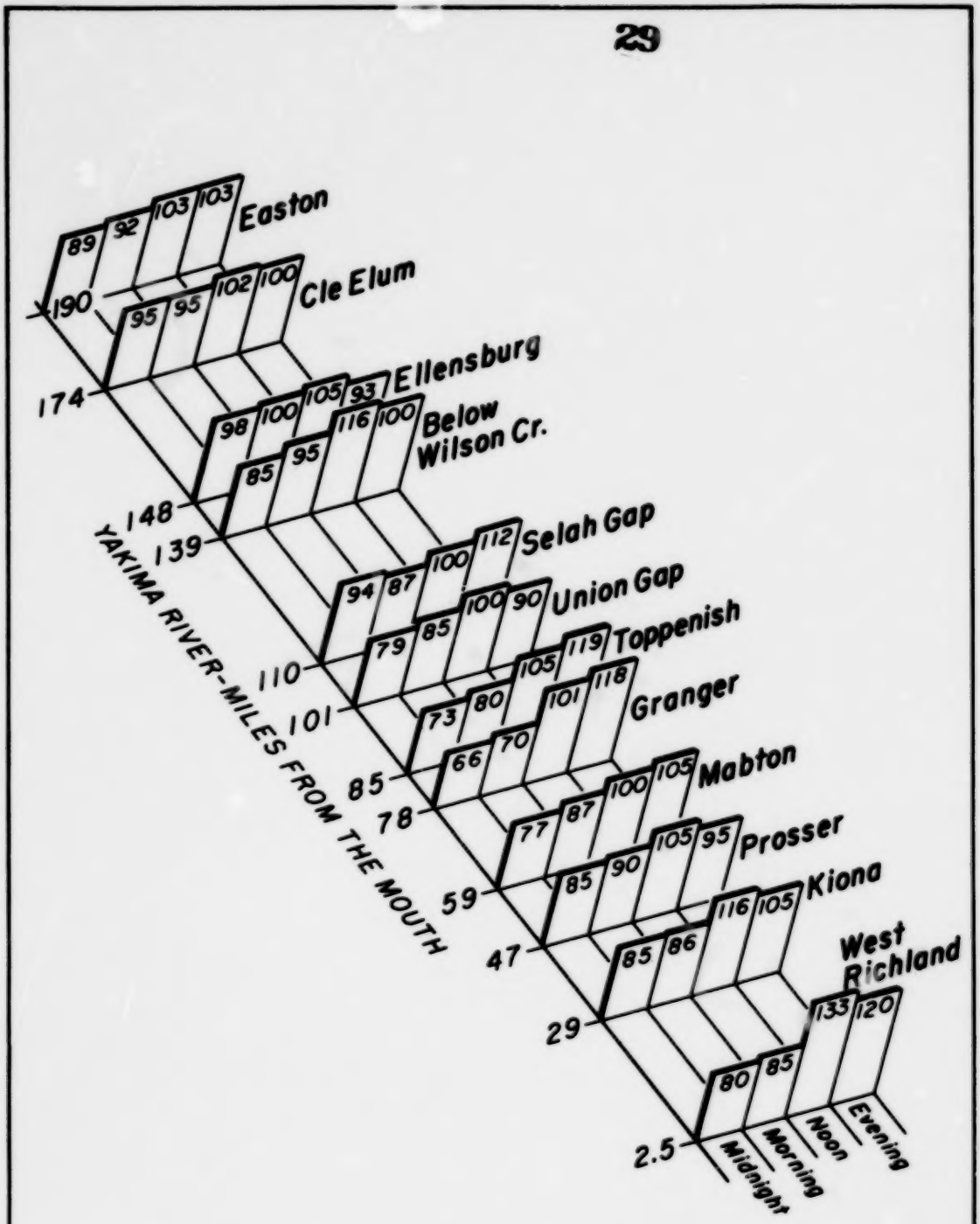
Organic matter, in terms of BOD, varies from less than 1 mg/1 in the upper reaches to an average of about 3 mg/1 below Union Gap. BOD values observed during 1961 and 1962 at three representative locations along the Yakima River (i.e., Selah Gap, Granger, and Prosser) are tabulated in APPENDIX B, Table 1.

The Public Health Service surveillance station near the mouth of Yakima River has detected DDD, DDE, DDT, and Dieldrin in river waters. The station has not been in operation long enough to ascertain the source or significance of these pesticide materials.

The chemical, physical, and biological quality of irrigation return flow has been studied by Sylvester* and by the Public Health Service. Data obtained in these studies show that turbidity, BOD, dissolved solids, coliform organisms, and temperature are somewhat higher in irrigation drains than in the river. It is also evident that drains contain high numbers of coliform organisms (see APPENDIX B, Table 5).

---

* Sylvester, R. O., "A Study on the Character and Significance of Irrigation Return Flows in the Yakima River Basin", University of Washington, February 1962.



WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

DISSOLVED OXYGEN, % SATURATION
SEPT. 19-20, 1961

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service
REGION IX (DATE 9/63) PORTLAND, OREGON

FIGURE V-7

B. Ground Water

1. Quantity

Ground water in Yakima River Basin is an important complement to the surface water resources of the area. Most of the municipalities in the basin, with the exception of Roslyn and Easton, utilize ground water for supply purposes. In addition, ground water is used extensively by self-supplied industries, rural residences, and irrigators. The U. S. Geological Survey lists the 1951 ground water withdrawals in the basin as:*

Irrigation.	23,900	acre-feet per year
Industrial.	14,600	acre-feet per year
Municipal	7,800	acre-feet per year
Domestic.	5,365	acre-feet per year
TOTAL	51,665	acre-feet per year

According to the USGS, the valley is composed of discreet ground water basins that have outlets roughly the same as the river outlets below Ellensburg, at Selah Gap, at Union Gap, and below Prosser.

2. Quality

Chemical analyses, including field determinations of hardness and chloride, have been run by the USGS on over 40 wells in the basin. The breakdown by formation is as follows:

	No. of Samples	Cl (ppm)	Hardness as $CaCO_3$
Yakima Basalt	6	1.2- 8	54-95
Ellensburg Formation. . .	9	6 - 26	75-240
Cemented Gravel	10	5 - 26	120-265
Unconsolidated Alluvium .	19	0.7- 14	49-148

*Sceva, Jack E., USGS, Water Resources Division, "Gehydraulic Evaluation of Stream Flow Records in the Yakima River Basin, Washington".

Data on several additional wells throughout the valley are shown in APPENDIX B, Table 6. The mineral content of ground water is higher than that of surface water, but is less than 500 mg/l (recommended standard) in nearly all cases. Some wells tapping the basalt aquifer reportedly contain small amounts of hydrogen sulfide.

Ground water quality in the Yakima River Basin appears to be acceptable for domestic use, with no treatment other than disinfection. However, many municipal water companies, including Grandview, Prosser, Sunnyside, Mabton, Toppenish, Selah, and Nob Hill, have treatment problems resulting from objectionable quantities of hydrogen sulfide and/or methane gas. A slime-like growth, at least partly attributable to the gas, has also been found in some well supplies.

VI. THE ECONOMY

A. General

The demand for water for municipal and industrial purposes, and the amount and character of waste waters resulting from such uses, are determined largely by the activities associated with a region's economic base. The purpose of this section is to present economic and demographic data to be used as a basis for projecting the needs for water for municipal and industrial purposes and for estimating the future amounts and types of waste and land drainage material that may be expected to occur in the Yakima River Basin with the expanded development anticipated in the future.

B. Present

1. Economic Activities

Employment by industry in the Yakima 3-County Area in 1960 is shown in Table VI-1. Table VI-2 shows the per cent of the total labor force in each industry group in the Yakima 3-County Area, and compares that distribution with the Seattle Region and with the United States as a whole. An estimated employment distribution for the Yakima Valley is shown in Table VI-2. The difference between the employment pattern in the Yakima Valley and the 3-County Area is mainly the result of the inclusion in the latter of the Hanford Atomic Works and various industries that have grown up as a result of it in Richland and Kennewick. In the industrial classification, the Hanford Atomic Works, with more than 6,000 employees, is classified as a "chemical" industry.

TABLE VI-1

LABOR FORCE, BY INDUSTRY GROUP, YAKIMA 3-COUNTY AREA, APRIL 1960

Industry Group	Individual Counties			3-County Total
	Benton	Kittitas	Yakima	
Agriculture	1832	1224	12155	15211
Forest management; fisheries	9	45	37	91
Mining	3	110	34	147
Manufacturing, Total	8097	629	6069	14795
Logging, lumber, wood pr.,furn.	17	269	951	1237
Primary & fabric. metals	48	45	138	231
Machinery, incl. electrical	31	20	317	368
Other durable goods	109	43	491	643
Food and kindred products	423	195	2657	3275
Textiles and apparel	13	0	340	353
Printing, publishing, and allied	272	53	560	885
Chemical and allied	7097[a]	0	297	7394[a]
Other non-durables, & misc. mfrs.	87	4	318[b]	409[b]
Construction	2179	825	3101	6105
Truck transp. and warehousing	189	142	1514	1845
R.R. & other transportation	426	154	689	1269
Wholesale trade	311	205	3051	3567
Retail trade	2770	1246	7472	11488
Education	1239	938	2491	4668
All other services[c]	4605	1617	11628	17850
Industry not reported	412	136	773	1321
Total Employed Civilian Labor Force	22072	7271	49014	78357
Military	826	24	281	1131
Total Employed Labor Force	22898	7295	49295	79488
Unemployed	1561	653	5563	7777
TOTAL LABOR FORCE	24459	7948	54858	87265

a/ More than 6000 of these employees were at the Hanford Atomic Works.
b/ Includes 213 in "Pulp, Paper, and Allied Products", according to Washington State covered employment data for April 1960.
c/ Includes communications and utilities; finance, insurance, real estate, business and repair services; personal services, private household workers, entertainment and recreation; professional and related services; and public administration.

Source: U. S. Census of Population, 1960.

TABLE VI-2

COMPARATIVE DISTRIBUTION OF LABOR FORCE, BY INDUSTRY GROUP, APRIL 1960
(As Percent of Total Labor Force)

Industry Group	Yakima Valley a/	3-County Area b/	Seattle Region c/	United States
Agriculture	21.3	17.4	4.5	6.1
Forest management; fisheries	.1	.1	.5	.1
Mining	.2	.2	.1	.9
Manufacturing, Total	10.6	17.0	24.1	25.1
Logging, lumber, wood pr., furn.	1.9	1.4	5.0	1.5
Primary and fabricated metals	.3	.3	1.6	3.6
Machinery, incl. electrical	.5	.4	1.1	4.4
Other durable goods	.8	.8	8.6 d/	4.6
Food and kindred products	4.5	3.8	2.6	2.6
Textiles and apparel	.6	.4	.6	3.1
Printing, publishing and allied	1.0	1.0	1.3	1.6
Chemical and allied	.5	8.5 e/	1.1	1.2
Other non-durables, and misc. mfrs.	.5	.4	2.2	2.5
Construction	6.3	7.0	5.8	5.5
Truck transp. and warehousing	2.6	2.1	1.2	1.3
R.R. and other transportation	1.3	1.5	3.1	2.6
Wholesale trade	5.2	4.1	3.7	3.2
Retail trade	13.9	13.2	13.5	13.7
Education	5.5	5.3	5.2	4.8
All other services f/	21.2	20.4	24.8	25.5
Industry not reported	1.4	1.5	2.6	3.7
Total Employed Civilian Labor Force	89.6	89.8	89.1	92.5
Military	.5	1.3	4.6	2.5
Unemployed	9.9	8.9	6.3	5.0
TOTAL LABOR FORCE	100.0	100.0	100.0	100.0

a/ Based on the distribution in Kittitas and Yakima Counties. It is assumed that the portion of Benton County included in the Yakima Valley has an employment pattern similar to the other two counties.
b/ Includes all of Benton, Kittitas and Yakima Counties.
c/ Defined as Washington State, less 5 counties in southwestern Washington (in the Portland Region) and 15 counties in eastern Washington (in the Spokane Region.
d/ Includes the Boeing Co. at Seattle.
e/ Includes the Hanford Atomic Works.
f/ See Table 1, note c.

Source: U. S. Census of Population, 1960.

The comparisons in Table VI-2 show that the economic base of the Yakima Valley depends primarily upon specialization in agriculture and food processing. There is also more employment in trucking, warehousing, and wholesale trade than would be expected on the basis of the employment pattern in the Seattle Region and in the United States. This is due to food-processing activities, and to the fact that the City of Yakima acts as a collection and distribution center for a somewhat larger area than the three counties. There is also above-"normal" employment in education, resulting from the Central Washington State College at Ellensburg and a junior college at Yakima. The larger than "normal" employment in construction is not considered to be part of the permanent economic base, but to result principally from unusual building activity in the area at the time of the 1960 census.1/

Table VI-3 provides data on the agricultural production of the Yakima 3-County Area. Of the 526,000 acres of crop land harvested in the 3-County Area in 1959, 345,000 were irrigated. In addition to this crop land irrigated, 113,000 more acres of land in uses other than for crops (pasture, etc.) were irrigated. Most of the irrigation is provided through organized irrigation districts, rather than by on-farm

---

1/ Construction activity at Wanapum Dam was near its peak in 1960, while at Priest Rapids Dam final construction, including installation of generators, was still under way. Employees at these two sites, most of whom lived in Kittitas and Yakima Counties, would account for much of the above-average employment in construction in the 3-County Area.

TABLE VI-3

ACREAGE HARVESTED, BY PRINCIPAL CROPS, YAKIMA 3-COUNTY AREA, 1959 a/

In Thousands of Acres

Type of Crop	Crops Harvested from Irrigated Acreage				Total Acreage, Including non-irrigated, 3-County Total
	Individual Counties			3-County Total	
	Benton	Kittitas	Yakima		
Corn	5.7	.9	41.5	48.1	49.3
Winter wheat	.9	.3	.4	1.6	113.8
Spring wheat	2.5	5.4	9.0	16.9	23.7
Oats	.6	5.9	2.0	8.5	9.6
Barley	.7	1.9	6.1	8.7	35.6
Beans, dry field and seed	1.1	-	-	1.1	1.1
Peas, dry field and seed	.1	.6	.2	.9	.9
Hay	8.9	42.8	44.9	96.6	104.1
Hops	1.3	-	17.0	18.3	18.3
Potatoes	2.3	1.3	4.5	8.1	8.2
Sugar Beets	2.1	.8	14.4	17.3	17.3
Asparagus	1.7	-	10.2	11.9	11.9
Sweet corn	.3	2.3	8.1	10.7	10.9
Tomatoes	-	-	1.1	1.1	1.1
Green peas	.8	.3	1.5	2.6	2.6
Orchards & vineyards	5.6	.2	61.4	67.2	69.0
Misc. & not classified	5.7	.2	19.8	25.7	48.4
TOTAL	40.3	62.9	242.1	345.3	525.8

a/ Includes all of Benton, Kittitas and Yakima Counties.

Source: U.S. Census of Agriculture, 1959, Washington State volume, Table 11a, page 206.

sources. With the exceptions of winter wheat and barley, nearly all crops are grown only on irrigated land. These provide the raw material for the basin's important food-products manufacturing industry. As shown in Table VI-3, orchards are a major component in the agricultural economy. Livestock and poultry are also important in the basin. Dairy, meat and poultry products from the Yakima Valley are shipped to cities throughout the Northwest, particularly to the populous Puget Sound area. Yakima County is the leading county in Washington State in value of farm products sold. It ranks first in the State in production of tree fruits, grapes, sugar beets, vegetables, cattle, sheep, and turkeys. It is also the leading county in the Nation in production of apples, hops, and mint.

2. Population

The population of the Yakima Valley was about 177,000 in 1960, and the population of the 3-County Area was about 228,000. The difference is due to the exclusion from the Yakima Valley of the most populous parts of Benton County, as shown in Table VI-4. Of the 177,000 in the Yakima Valley, 145,000 were in Yakima County. Data are also presented in Table VI-4 for a "Yakima Urban Area", which includes the suburban development surrounding the City of Yakima, as well as the population within the incorporated limits of the city. The boundaries used for this "urban area" are described in footnote "b" of Table VI-4.

TABLE VI-4
POPULATION, BY COUNTY AND INCORPORATED PLACES,
YAKIMA VALLEY ECONOMIC AREA AND 3-COUNTY AREA

County or City	1940	1950	1960
KITTITAS COUNTY, TOTAL	20230	22235	20467
Cle Elum	2230	2206	1816
Ellensburg	5944	8430	8625
Kittitas	501	586	536
Roslyn	1743	1537	1283
South Cle Elum	n.a.	442	383
Unincorporated [a]	9812	9034	7824
YAKIMA COUNTY, TOTAL	99019	135723	145112
Yakima Urban Area [b]	n.a.	60648	65608
Yakima City	27221	38486	43284
Union Gap City	976	1766	2100
Unincorporated suburban [b]	n.a.	20396	20224
Grandview	1449	2503	3366
Granger	752	1164	1424
Harrah	n.a.	297	284
Mabton	485	831	958
Moxee City	335	543	499
Naches	536	633	680
Selah	1130	2489	2824
Sunnyside	2368	4194	6208
Tieton	n.a.	620	479
Toppenish	3683	5265	5667
Wapato	1483	3185	3137
Zillah	803	911	1059
Unincorp. outside Yakima urban area [a]	n.a.	52440	52919
BENTON COUNTY, TOTAL	12053	51370	62070
BENTON COUNTY INSIDE YAKIMA VALLEY, TOTAL	n.a.	8697	11631
Benton City	n.a.	863	1210
Prosser	1719	2636	2763
West Richland	n.a.	n.a.	1347
Unincorp. portion of CCD's 12,13,14 [a]	n.a.	5198	6311
TOTAL, YAKIMA VALLEY [c]	n.a.	166655	177210
BENTON COUNTY, OUTSIDE YAKIMA VALLEY, TOTAL	n.a.	42673	50439
Kennewick	1918	10106	14244
Richland	n.a.	21809	23548
Unincorporated	n.a.	10758	12647
TOTAL, YAKIMA 3-COUNTY AREA [d]	131302	209328	227649

Footnotes on following page.

TABLE VI-4 (continued)
POPULATION, BY COUNTY AND INCORPORATED PLACES,
YAKIMA VALLEY ECONOMIC AREA AND 3-COUNTY AREA

---

a/ Includes all unincorporated areas as of year shown, including portions marked "n.a." (not available) which were later incorporated.

b/ Defined to include Yakima County 1960 Census Divisions 9,10,11,12,15, 16,17,18,19, and Yakima City. Included within these divisions are the City of Union Gap and the unincorporated communities of Fairview, Fruitvale, South Broadway and Sumach.

c/ Includes all of Kittitas and Yakima Counties and Census County Divisions 12,13,14, and "Prosser" in Benton County.

d/ Includes all of Kittitas, Yakima and Benton Counties.

SOURCE: U. S. Census of Population, 1940, 1950, 1960, April 1.

C. Projected Economic Base and Population

1. Future Increases in Output and Employment of Major Industries

a. Summary

The economy of the Yakima Valley is heavily dependent upon agriculture and food processing, with some additional specialization in lumber and wood products manufacturing, trucking, warehousing, wholesaling, and education. Future growth of the Valley's economy and population will depend primarily upon expansion of these same industries. The only other growth factors foreseeable are the possibilities of increased employment in services connected with recreation, the spill-over effects that would be felt from further development and diversification at Hanford, the proposed development of coal mines near Cle Elum, and the stimulus that might result if barge navigation on the Columbia River is extended to Wenatchee.

b. Agriculture

It is assumed that there will be no significant increase in total acreage, but that irrigated acreage will increase slowly during the study period. A rate of growth in irrigated acreage of 0.2 per cent per year has been adopted for this study.

It is assumed that cattle population in the Yakima Valley will increase at about the rate projected for the population of Washington State, or about 2.0 per cent per year. That same rate of increase has also been assumed for hogs and pigs, whose number in the 3-County Area increased substantially from 1954 to 1959. It is

assumed that poultry numbers in the Yakima Valley will increase at only half the rate expected for State population, or at about 1.0 per cent per year. This also approximates the rate of increase in poultry production in Yakima County during 1954-59. It is assumed in this report that the number of milk cows in the Yakima Valley will slowly increase at 0.5 per cent per year. On the basis of the growth rates assumed above, animal populations in the Yakima 3-County Area in the future would be as follows:

	1959	1985	2010
Milk Cows	19,766	22,500	25,500
Other Cattle	198,211	331,700	544,200
Hogs & Pigs	25,636	42,900	70,400
Chickens	334,503	433,300	555,600

It is assumed here that average productivity per acre in the Yakima Basin will increase at 2 per cent per year during the study period.

c. Food Processing

On the basis of preceding assumptions, the raw material for food processing in the Yakima Valley would increase at about 2.2 per cent per year (0.2 per cent from increases in acreage, and 2.0 per cent from increases in productivity per acre). Additional increases are expected as a result of diverting irrigated land presently used for hay and grains to specialty crops to be used in freezing and canning. It is assumed that the combined effect of these factors will be that the raw materials available for food processing and the output of food-processing plants in the Yakima Valley in 1985

will be about double the 1960 level and, in 2010, about four times the 1960 level. For purposes of this study, it is further assumed that this same growth rate will apply to all crops now processed, so that the relative proportions among the various food products will remain the same in the future as at present. It is assumed here that the growth in food processing will represent expansion at or near existing plants. This assumption might have to be revised if river barge navigation is extended from Pasco to Wenatchee, in which case there might be some advantages in locating plants along the Columbia River.

d. Lumber and Wood Products

There appears to be the possibility of expansion in production and employment in this industrial category based upon harvesting species which are not now being cut, such as lodgepole pine, larch, Engleman spruce, mountain hemlock, and alpine fir. This could provide the raw material for manufacture of pulp or hardboard or other wood composition products. Because of the large pulp and paper facilities already well established over the Cascades in Western Washington and because the transportation of chips across the mountains from Chelan County has already proved to be economically feasible, it seems unlikely that additional pulp or paper capacity will be built in the Yakima Basin. The most likely use of secondary species manufactured within the Yakima Basin would be for hardboard or particle board. It is assumed, for purposes of estimating industrial wastes, that two such plants will be established during the study period, with Cle Elum and Yakima the most likely sites.

It is assumed that the harvest of major species now being cut in the Yakima Basin will remain about at the present level throughout the study period. There can be some increase in employment in this sector, however, due to increases in fabricating of secondary products, though such an increase will be partly offset by increases in output per man hour.

e. Coal Mining

Coal reserves in the Yakima Basin, located in Kittitas County near Roslyn and Cle Elum, are estimated at 241 million tons. A tentative proposal has been made by a group of PUD's to re-activate the mines there, which are now virtually closed, for thermal power purposes. Whether the coal mines are re-opened for this purpose will depend on the relative cost advantages between coal-fired and nuclear-fired steam power generation. It is assumed in this study for water resource planning purposes that a 500,000 kw steam-power plant will be in operation near the coal deposits by 1985. Such a plant would require about 1.3 million tons of coal per year of the quality found in Kittitas County and would employ about 300 persons in mining and generating plant operations.

f. Diversified Manufacturing

With the growth in the size of the local economy, it is anticipated that there will be a more than proportionate growth in the local manufacture of products now imported into the area. Table VI-2 shows how the percentage of the labor force in the Yakima Valley in most manufacturing categories falls far below that in the Seattle Region

and the United States. It is expected that with growth the Yakima Valley will tend to move in the direction of the greater diversification characteristic of the larger areas. This would mean increases in employment in such classifications as fabricated metals, machinery, "other durables", and "other non-durables".

g. Service Industries

It is assumed that Yakima will continue to act as a center for trucking, warehousing, and wholesaling services, and that employment in them will increase with the increase in State population.

The State college at Ellensburg doubled in number of students during the past decade and is expected to double again during the next decade. It is assumed here that the growth of the college will continue during the study period, although at a slower rate during the latter part of the period.

h. Recreation

There appear to be possibilities for development of recreation and tourism activities along the eastern slopes of the Cascades. This would add to the economic base of the area and contribute to the increase in employment in "all other services", as shown in Table VI-5.

2. Future Labor Force

On the basis of the preceding assumptions, an illustrative distribution of the labor force in the Yakima 3-County Area in 1985 and 2010 is given in Table VI-5.

TABLE VI-5

ESTIMATED FUTURE POPULATION OF THE YAKIMA 3-COUNTY AREA AND AN ILLUSTRATIVE DISTRIBUTION OF THE FUTURE LABOR FORCE, 1960-2010[a/]

Industry Group	Employment, nearest thousand 1960	1985	2010
Agriculture, forest management, fisheries, and mining	15.5	16	17
Manufacturing. Total	14.8	25	37
Logging, lumber, wood prod., furn.[b/]	1.2	2	3
Primary and fabricated metals, machinery, transp. equip., and all other durables	1.2	4	7
Food and kindred products	3.3	5	7
Chemicals and allied	7.4	10[c/]	12[c/]
Textiles, apparel, printing, and other non-durables, and misc. mfr.	1.7	4	8
Trucking and warehousing	1.8	3	5
Education	4.7	8	11
All other services, including construction and "industry not reported"	41.6	61	89
Total Employed Civilian Labor Force	78.4	113	159
Military	1.1	1	2
Total Employed Labor Force	79.5	114	161
Unemployed	7.8	7	8
Unemployed as percent of total employed labor force	(9.8%)	(6.1%)	(5.0%)
Total Labor Force	87.3	121	169
Population (nearest thousand)	228	314[d/]	434[d/]
Total labor force as percent of population	(38.3%)	(38.5%)	(39%)

a/ Includes all of Benton, Kittitas and Yakima Counties.
b/ Includes hardboard, etc.
c/ It is assumed that the Hanford atomic works will continue, with some moderate expansion in employment, and that there will be growth of other more conventional chemical manufacturing, particularly in the field of agricultural chemicals.
d/ Also corresponds to projections in North Cascade Mountains Study, CBIAC, Jan. 1964, Part I, Table 1, page 42.

3. Estimated Future Population

Table VI-5 gives an estimate of population in the Yakima 3-County Area in 1985 and 2010. The growth rate for the 3-County Area's population would be 1.3 per cent per year during both the 1960-85 and 1985-2010 periods.

As shown in Table VI-4, the portion of the Yakima 3-County Area's population that was within the Yakima Valley was 79.6 per cent in 1950 and 77.8 per cent in 1960. Although it is assumed that the Richland-Kennewick area will grow less rapidly in the future than it has in the past, it is anticipated that the population in the Yakima Valley will probably continue to decline slowly as a percentage of the 3-County Area. Here, it is assumed that the Yakima Valley will constitute 76 per cent of the 3-County Area's population in 1985 and 75 per cent in 2010. These percentages applied to the preceding projections for the 3-County Area would mean that population within the Yakima Valley would be:

1960	177,000
1985	239,000
2010	326,000

The incorporated places in the Yakima Valley, as shown in Table VI-4, and including the entire Yakima City Urban Area, as defined in that table, constituted about 60 per cent of the total Valley population in 1950 and about 62 per cent in 1960. It is assumed that this trend will continue and that population in incorporated places in 1985 will represent about 67 per cent of the Valley population in 1985 and about 72 per cent in 2010. This would mean that

population in incorporated places in the Valley would be 160,000 in 1985 and 235,000 in 2010. The growth rate for incorporated places, taken as a whole, would be about 1.6 per cent per year during the study period. The bulk of the growth is likely to be in the Yakima Urban Area, with Ellensburg and the Cle Elum-Roslyn area also participating because of the economic base factors discussed above. Table VI-6 provides a general guide to the growth that might reasonably be expected to occur in each city. Table VI-6 should be regarded as simply a working hypotheses for planning purposes.

In order to facilitate planning for water supplies and waste disposal, the Yakima Valley has been divided into six service areas, and the projected future population of the Valley has been distributed among these areas, as shown in Table VI-7. The distribution of unincorporated population has been made on the basis of a judgment as to the potential for expansion of agriculture in the various areas and the probabilities of growth in suburban population.

TABLE VI-6

ILLUSTRATIVE PROJECTIONS OF FUTURE POPULATION IN INCORPORATED PLACES
YAKIMA VALLEY

(Population to nearest thousand)

City or Area	1960	1985	2010
Kittitas County:			
Cle Elum, South Cle Elum, and Roslyn (total population)	3.5	5.0	7.4
Ellensburg	8.6	12.5	18.1
Kittitas	.5	.6	.7
Yakima County:			
Yakima Urban Area[a/]	65.6	100.0	153.0
Grandview	3.4	4.9	7.2
Granger	1.4	2.0	2.9
Harrah	.3	.3	.4
Mabton	1.0	1.4	2.0
Moxee City	.5	.6	.7
Naches	.7	.8	.9
Selah	2.8	4.1	5.9
Sunnyside	6.2	9.0	13.0
Tieton	.5	.6	.7
Toppenish	5.7	6.4	7.3
Wapato	3.1	3.6	4.0
Zillah	1.1	1.5	2.2
Benton County (portion in Yakima Basin):			
Benton City	1.2	1.7	2.3
Prosser	2.8	3.1	3.5
West Richland	1.3	1.9	2.8
TOTAL, INCORPORATED PLACES IN YAKIMA BASIN	110.2	160.0	235.0

a/ For definition of Yakima Urban Area, see Table 8 footnote[b/].

TABLE VI-7

PROJECTED FUTURE POPULATION IN THE YAKIMA VALLEY, BY SERVICE AREAS
(Population to nearest thousand)

Area	1950	1960	1985	2010
Cle Elum - Roslyn Area[a/]	6.5	4.8	6.7	9.5
Incorporated places[b/]	4.2	3.5	5.[illegible]	7.4
Unincorporated	2.3	1.3	1.7	2.1
Ellensburg - Kittitas Area[c/]	15.7	15.7	21.6	29.3
Incorporated places[d/]	9.0	9.2[m/]	13.1	18.8
Unincorporated	6.7	6.5	8.5	10.5
Naches - Yakima - Moxee City Area[e/]	84.6	89.2	128.1	186.1
Incorporated places[f/]	64.9	70.1	106.1	161.2
Unincorporated	19.7	19.1	22.0	24.9
Wapato - Toppenish Area[g/]	28.0	28.5	33.4	38.7
Incorporated places[h/]	9.7	10.1[m/]	11.8	13.9
Unincorporated	18.3	18.4	21.6	24.8
Sunnyside - Grandview Area[i/]	23.1	27.4	35.4	45.9
Incorporated places[j/]	8.7	12.0	17.3	25.1
Unincorporated	14.4	15.4	18.1	20.8
Prosser - Benton City Area[k/]	8.7	11.6	13.8	16.5
Incorporated places[l/]	n.a.	5.3	6.7	8.6
Unincorporated	n.a.	6.3	7.1	7.9
TOTAL YAKIMA VALLEY	166.6	177.2	239.0	326.0
Incorporated places	n.a.	110.2	160.0	235.0
Unincorporated	n.a.	67.0	79.0	91.0

a/ Kittitas County Census Divisions 2, 3, 4, 5, and 6.
b/ Roslyn, Cle Elum, and South Cle Elum.
c/ Kittitas County Census Divisions 1, 7, 8, 9, 10, and Ellensburg.
d/ Kittitas and Ellensburg.
e/ Yakima County Census Divisions 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, Selah and Yakima.
f/ Includes Yakima and Union Gap, and certain unincorporated suburban area as defined in footnote "b" in Table 8, and also Tieton, Naches, Selah, and Moxee City.
g/ Yakima County Census Divisions 21, 22, 23, 24, 25, 26, 27, 33, 34, 35, 36, 37, 39, 40, Toppenish and Wapato.
h/ Harrah, Toppenish, Wapato, and Zillah.
i/ Yakima County Census Divisions 28, 29, 30, 31, 32, 38, and Sunnyside.
j/ Grandview, Granger, Mabton and Sunnyside.
k/ Benton County Census Divisions 12, 13, 14, and Prosser.
l/ Benton City, Prosser, West Richland.
m/ Differs from data shown in Table 10 because of rounding.

VII. WATER REQUIREMENTS--MUNICIPAL AND INDUSTRIAL

A. Present Water Use

Water use in the study area in 1960 for municipal and domestic purposes was about 36 MGD and for industrial purposes about 9 MGD. Approximately 70 per cent of the water used for these purposes is obtained from underground sources. Pertinent information on water supplies in the basin are summarized in TABLE VII-1 and are further described below.

1. Cle Elum-Roslyn Area

The Cle Elum-Roslyn water-service area had a 1960 population of 4,800, of which 3,500 lived in incorporated places and 1,300 lived in unincorporated areas. A meat-packing plant, located near Cle Elum, was the only major industrial water user in the area. Municipal water needs were supplied primarily from surface water. The average 1960 municipal and domestic use was 1.1 MGD or 1,230 acre-feet. The industrial use averaged 0.1 MGD.

2. Ellensburg-Kittitas Area

The 1960 population of the Ellensburg-Kittitas area was 15,700, of which 9,200 lived in incorporated places and 6,500 lived in unincorporated areas. The Ellensburg water supply is obtained from wells, and the supply at Kittitas is from springs. Water use in this area for municipal and domestic purposes in 1960 averaged 3.1 MGD or 3,470 acre-feet. Industrial water use by three slaughter houses, a rendering plant, a dairy, and a cannery averaged 0.4 MGD, with 0.87 MGD used in September and 0.28 MGD used in January.

TABLE VII-1
WATER SUPPLY INVENTORY

Community	Pop. Served	Source of Supply	Ave. Plant Output, MGD 1/	Treatment
Benton City	1,210	3 wells	0.30	None
Cle Elum	2,000	Lake Cle Elum, river, springs, and wells.	2.00	Chlorination
Easton	300	Silver Creek	0.06	None
Ellensburg	9,500	4 wells	2.689	Chlorination
Grandview	4,000	6 wells	1.80	Chlorination
Granger	1,530	2 wells	0.10	None
Kittitas	500	Spring	0.65	None
Mabton	980	3 wells	0.09	Chlorination, Aeration
Moxee	600	Well	0.15	None
Naches	650	2 wells	0.04	None
Prosser	3,250	3 wells	0.83	Chlorination, Aeration
Ronald	250	Roslyn	---	See Roslyn
Roslyn	1,600	Domeric Creek	0.24	Chlorination
Selah	3,200	4 wells	0.80	None
South Cle Elum	415	Springs	0.02	Chlorination
Sunnyside	6,200	6 wells	1.44	Chlorination
Tieton	460	2 wells	0.11	None
Toppenish	6,000	4 wells	1.50	None
Union Gap	2,100	3 wells	0.53	None
Wapato	3,135	3 wells	1.02	Chlorination
West Richland	800	2 wells	0.20	None
Yakima	43,000	Naches R. (winter) 4 wells (summer)	11.50 8.20	Chlorination
Zillah	1,200	3 wells	0.30	None
Misc. Water Districts		wells	1.00	

1/ Estimated or based on actual plant output.

3. Naches-Yakima-Moxee City Area

The 1960 population of this area was 89,200, of which 70,100 persons lived in incorporated places and 19,100 lived in unincorporated places. The Yakima supply is obtained mainly from surface sources by rights to 10 cfs from the Naches River at Oak Flat and by contract with the Bureau of Reclamation for 6,000 acre-feet of storage. The supply is obtained from infiltration galleries along the Naches River and supplemented by five city wells during high-demand, low-flow periods. An irrigation system and numerous privately owned industrial wells augment the municipal system. Other communities in this area utilize ground water. Food processing industries account for the area's major industrial water use. The 1960 municipal demand in the water service area was about 19.9 MGD or 22,300 acre-feet. The annual industrial demand averaged 1.4 MGD, and ranged from an estimated monthly average low of 0.83 MGD in January to a maximum of 3.87 MGD in September.

4. Wapato-Toppenish Area

The 1960 population of this area was 28,500, of which 10,100 were located in incorporated places and 18,400 were in unincorporated places. Water use for municipal and industrial purposes in 1960 was about 4.8 MGD or 5,380 acre-feet, of which 4.4 MGD was for sugar refining, meat packing, and other types of food processing. The maximum industrial demand occurs in September (8.7 MGD) and falls to about 0.02 MGD in "off" seasons.

5. Sunnyside-Grandview Area

The 1960 population of this area was 23,100, of which 8,700 resided in incorporated places and 14,400 resided in unincorporated places. Ground water constitutes the main source of municipal and industrial supply, and in 1960 about 4.9 MGD or 5,490 acre-feet was used. Industrial use was about 1.8 MGD, with maximum monthly use occurring in October (2.7 MGD) and minimum use occurring in May (1.36 MGD).

6. Prosser-Benton City Area

The 1960 population in this service area was 11,600, of which 5,300 lived in incorporated places and 6,300 lived in unincorporated areas. Food processing, as in many other areas, constitutes the major industrial water use. The municipal and domestic demand in 1960 averaged about 2.1 MGD or 2,350 acre-feet. Industrial demands varied from 2.25 MGD in November to 0.15 MGD in January, and averaged 0.9 MGD for the year. All supplies are obtained from ground water sources.

B. Forecast of Future Water Needs

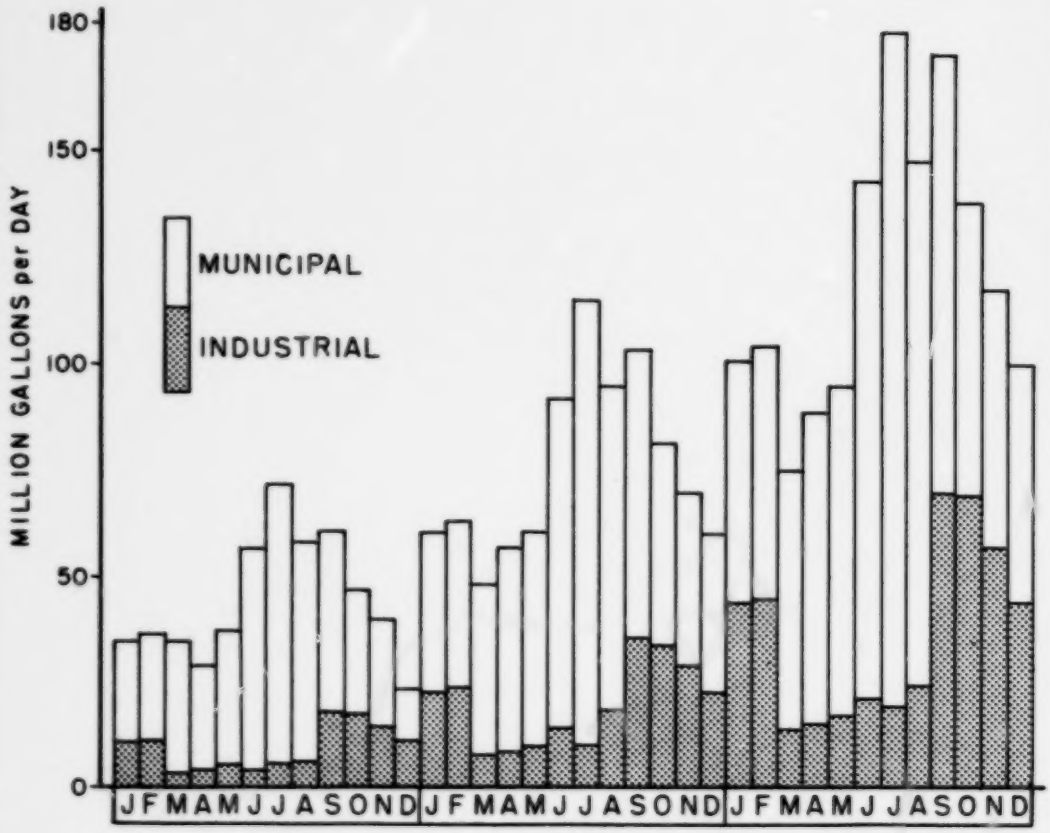
The projected municipal, domestic, and industrial needs by service areas are summarized in TABLE VII-2, and are shown graphically for the entire area in FIGURE VII-1. Municipal and domestic water needs were projected by applying per capita water usage data to the population projections shown in TABLE VI-7 (Page VI-17). The per capita figures were derived from data on 196 communities in the Pacific Northwest in which climate, size of community, availability of water, living standards, and other factors were taken into account. Values derived

TABLE VII-2
PRESENT AND FUTURE MUNICIPAL AND INDUSTRIAL NEEDS
BY WATER SERVICE AREAS, YAKIMA RIVER BASIN

Water Service Area	Municipal-Domestic Needs		Industrial Needs	
	Ave. MGD	Annual Ac.-Ft.	Ave. MGD	Annual Ac-Ft.
1960:				
Cle Elum-Roslyn	1.1	1,235	0.1	112
Ellensburg-Kittitas	3.1	3,480	0.4	449
Naches-Yakima-Moxee	19.9	22,400	1.4	1,570
Wapato-Toppenish	4.8	5,390	4.4	4,940
Sunnyside-Grandview	4.9	5,500	1.8	2,020
Prosser-Benton City	2.1	2,360	0.9	1,010
TOTAL.	35.9	40,365	9.0	10,101
1985:				
Cle Elum-Roslyn	1.6	1,795	0.2	224
Ellensburg-Kittitas	4.9	5,500	0.8	898
Naches-Yakima-Moxee	32.8	36,800	2.8	3,140
Wapato-Toppenish	6.8	7,630	8.8	9,880
Sunnyside-Grandview	7.4	8,300	3.6	4,040
Prosser-Benton City	2.9	3,260	1.7	2,020
TOTAL.	56.4	63,285	17.9	20,202
2010:				
Cle Elum-Roslyn	2.6	2,920	0.4	448
Ellensburg-Kittitas	8.3	9,310	1.6	1,796
Naches-Yakima-Moxee	53.1	59,600	5.6	6,280
Wapato-Toppenish	8.0	8,980	17.6	19,760
Sunnyside-Grandview	10.9	12,250	7.2	8,080
Prosser-Benton City	3.8	4,260	3.3	4,040
TOTAL.	86.7	97,320	35.7	40,404

Monthly Variation of Demand-%

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Municipal-Domestic Needs, All Areas	67	70	71	86	90	143	186	145	121	81	72	66
Industrial Needs												
Cle Elum-Roslyn	100	100	100	100	100	100	100	100	100	100	100	100
Ellensburg-Kittitas	70	73	72	81	129	134	91	79	218	145	73	70
Naches-Yakima-Moxee	59	61	71	64	60	74	79	88	276	216	164	65
Wapato-Toppenish	178	178	5	13	21	25	13	26	198	195	178	178
Sunnyside-Grandview	90	91	84	80	76	96	94	98	109	151	135	85
Prosser-Benton City	16	32	23	26	51	73	89	152	194	195	250	21



WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

MUNICIPAL & INDUSTRIAL
WATER DEMANDS

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION IX (DATE: 8/65) PORTLAND, OREGON

FIGURE VII-1

for this study area ranged from 250 gallons per capita per day (GPCD) in 1960 to 280 GPCD by 1985 and 305 GPCD by 2010. The figures were applied directly to the projected populations for incorporated places and to one-half of those projected for unincorporated places, since less densely settled areas do not support an appreciable number of commercial, institutional, or other users of this type.

Industrial water needs were projected for each area by combining demand data available on each plant. While these figures apply only to one particular season of operation, they provide a reasonable base upon which to project future needs. Because production data were not available, projections were based on expected growth in employment.

Municipal and industrial water use in 1960 was approximately 45 MGD. The potential demand for water for these purposes by years 1985 and 2010 is projected to be about 74 MGD and 122 MGD, respectively. The industrial demand has been and is expected to continue to increase at a slightly greater rate than the municipal demand.

VIII. WATER QUALITY CONTROL

A. Need for Control

1. General

Surface waters, in addition to being used for municipal and industrial supply, are used for irrigation, fish and game propagation, stock watering, recreation, hydroelectric power, and disposal of municipal and industrial waste. Stream waters in lower basin areas receive and at times consist almost entirely of return flows and drainage water from irrigated lands.

2. Irrigation

More water is used for irrigation in the basin than for any other purpose. The total area for which water is delivered is about 450,000 acres, and the cultivated area to which water is actually applied is about 375,000 acres. Diversion rates per acre average about 6.5 acre-feet. Water deliveries to farms average about 4.2 acre-feet per acre, and water actually applied averages about 3.5 acre-feet per acre. FIGURE V-2 (Page V-2) shows the general location of land areas irrigated at the present time. The mineral quality of water, according to agricultural standards, is suitable for irrigation, including return flow that is reused for this purpose in lower portions of the basin.

3. Municipal and Industrial Water Supply

Water from surface sources in the study area serves about 47,000 persons and a number of food processing industries. The chemical

quality of water for this use is generally within the limits of the U. S. Public Health Service Drinking Water Standards (i.e., total solids are less than 500 mg/l and analyses indicate that toxic or other mineral ions are not in excess of standards). Maximum water temperatures (75-plus degrees Fahrenheit) in the lower river below Yakima are generally higher than would be desirable to municipal and industrial use.

4. Fisheries

Anadromous fish runs in the Yakima River and its tributaries have historically been plagued by passage difficulties inherent in the extensive system of dams, diversions, and canals existing in the Yakima River Basin and by low flows resulting either from irrigation diversions or filling of reservoirs. The major problem is inadequate flows to allow passage, spawning and rearing of salmonoid species.

Species of anadromous fish utilizing the system include spring and fall chinook salmon, silver salmon, sockeye salmon, and steelhead. Resident game fish include rainbow trout, cutthroat trout, Dolly Varden, eastern brook trout, brown trout, Kokanee, mountain whitefish, ling, black bass, and crappie. The resident fish populations are augmented by average annual stocking of 390,000 catchable rainbow trout and 465,000 cutthroat and eastern brook trout fingerlings by Washington Department of Game. Non-game fish in the system include squawfish, suckers, carp, sculpins, shiners, dace, and other miscellaneous fish.

Since about 1920, fishery groups have been actively engaged in acquiring fish passage facilities at dams and diversions in the system. Rehabilitation studies by fishery agencies indicate that the potential fishery, if restored, would have an annual value in excess of 4 million dollars. These values do not include benefits that may accure from regulation of the Indian subsistence fishery, the regulation of which is considered to be essential to the development of the anadromous fishery in the basin.

Annual reports of the Washington State Department of Fisheries (1962-63) indicate that about 500 to 8,000 anadromous fish per year pass over Roza Dam and that a similar number spawn in the Naches River. About 2,000 to 8,000 fish are taken annually by the Yakima Indians with dip nets. General recommendations by the fishery agencies are that:

(a) Supplemental storage and existing projects within the Yakima Basin should be constructed and operated to maintain adequate flows for fish passage and propagation;

(b) Fish-protective and passage facilities should be constructed and maintained to assure full use of spawning and rearing areas in the Yakima Basin.

(c) Sports, commercial, and Indian subsistence fishing should be so regulated that it does not decrease escapement to spawning areas and thereby inhibit future runs.

5. Recreation and Riverside Uses

Water-oriented recreation, aside from fishing, is not as extensive in the lower basin as it is in the upper basin. There is some unorganized

swimming in the lower river and in irrigation canals. Most waters in the lower areas are not suitable for swimming due to high bacterial content, murkiness of the water, and excessive aquatic growths. In upper basin reservoir areas, recreational activities are on the increase and may be expected to reach major proportions. Many homes and cottages have been built on national forest lands adjacent to the upper Naches River. A few parks and picnic facilities have also been developed along the upper reaches of both the Naches and Yakima Rivers. Periodic flooding and unstable banks, however, discourage bank-side uses in many areas.

B. Municipal, Industrial, & Agricultural Pollution

1. Municipal

Municipal and domestic raw waste production in the Yakima River Basin is distributed approximately in direct proportion to the populations of the six water-service areas shown in TABLE VI-7 (Page VI-17). For purposes of computing flow requirements for quality control, the sewage wastes produced by populations in incorporated places and by one-half of the populations in unincorporated places were assumed to be collected and treated prior to discharge to the Yakima River. The balance of wastes produced in unincorporated areas were assumed to be treated in individual facilities, such as septic tanks, and would not, therefore, be discharged directly to surface waters. Other waste constituents, such as those contained in storm overflow and urban drainage, are not identified as such in the overall load determination but are assumed to be included in the loading added for unincorporated areas.

Monthly average waste production is relatively constant in much of the area, except in the lower valley during summer months. Production in July, August, and September is about 40 per cent greater than that for other months in the area below the confluence of the Naches and Yakima Rivers. This was taken into account in projecting future waste loads expected to be received in the lower river.

Nearly all municipal wastes are subjected to secondary treatment before disposal of the effluent. The Federal Grant Program of the U. S. Public Health Service has aided the construction of improvements and enlargements to municipal waste treatment facilities in the valley costing $2,779,248, with grant monies amounting to $833,503 from 1957 to 1963. The Cities of Cowiche, Grandview, Harrah, Prosser, Sunnyside, Tieton, and Yakima were recipients.

In projecting municipal waste loads for the area, secondary waste treatment or its equivalent for 85 per cent BOD removal was adopted. This waste treatment requirement is considered reasonable for the Yakima River Basin. The Washington State Pollution Control Commission also requires 85 per cent overall BOD reduction and effluent chlorination of municipal wastes.

The current and projected municipal waste loads for the six service areas are presented in TABLE VIII-1. Major municipal loading points on the Yakima River occur from the Naches River to Prosser, with the predominant load occurring in the Naches-Yakima-Moxee City area. Total municipal and industrial raw waste production is illustrated in FIGURE VIII-1.

TABLE VIII-1
MUNICIPAL WASTE LOADINGS
(1,000 Population Equivalents)

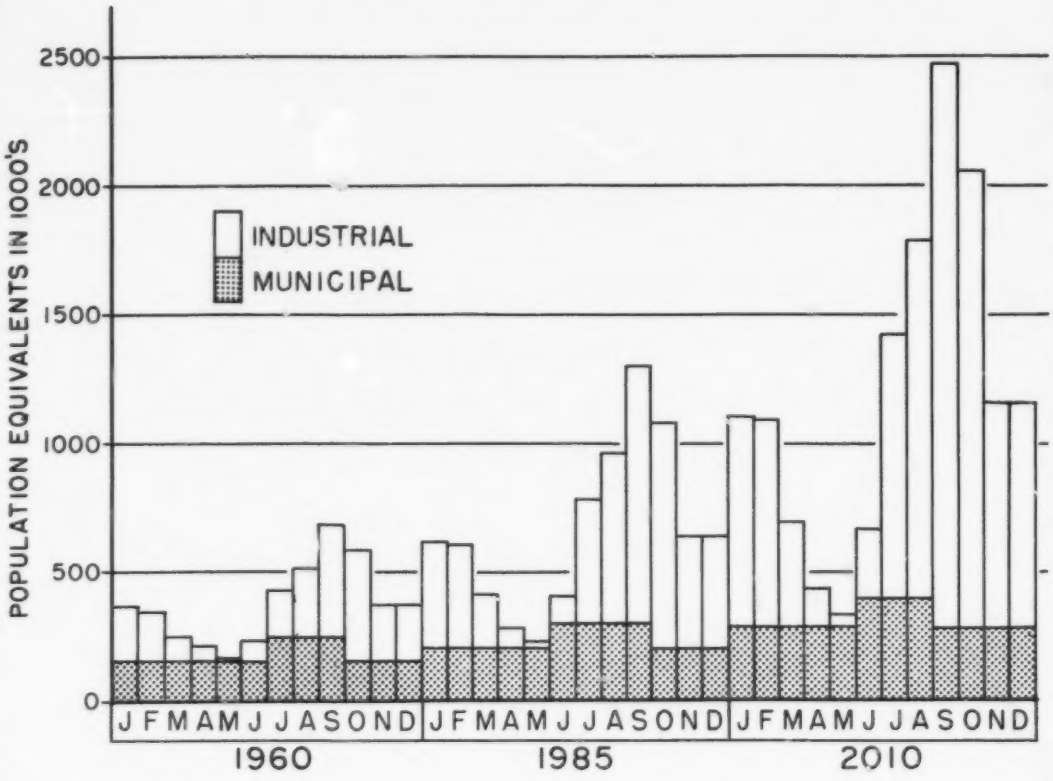
Area Served	Raw Load			Treated Load (85%)		
	1960	1985	2010	1960	1985	2010
Cle Elum-Roslyn	4.1	5.9	8.4	0.6	0.9	1.3
Ellensburg-Kittitas	12.4	17.3	24.0	1.8	2.6	3.6
Naches-Yakima-Moxee City	124.2	181.1	266.7	18.6	27.2	40.0
Wapato-Toppenish	33.5	39.3	45.6	5.0	5.9	6.8
Sunnyside-Grandview	33.4	44.1	58.5	5.0	6.6	8.8
Prosser-Benton City	14.3	17.6	20.8	2.1	2.6	3.1
TOTAL (Rounded)	222	305	424	33	46	64

2. Industrial

Industrial wastes in the study area are those produced mainly in the processing of foods and are highly variable in strength and quantity. Raw industrial waste production for 1960 by months for each water-service area is shown in TABLE VIII-2.

Future industrial waste projections were, for design purposes, derived from economic projections detailed in Chapter VI. Based on 1960 wastes, the projected wastes are expected to double by 1985 and to quadruple by the year 2010. (See FIGURE VIII-1)

Much of the industrial waste in the valley is controlled by spray irrigation and non-overflow lagoons, which allow little direct discharge of waste to the streams. Because relatively high treatment efficiencies can be attained and because the Washington State Pollution Control Commission is pressing for high removals of the industrial wastes from the streams, it is reasonable to expect that future efficiencies will be in excess of 85 per cent BOD removal.



WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

MUNICIPAL & INDUSTRIAL
RAW WASTE PRODUCTION

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION IX (DATE: 8/65) PORTLAND, OREGON

FIGURE VIII-1

TABLE VIII-2
INDUSTRIAL RAW WASTE PRODUCTION, 1960[1/]
(1,000 Population Equivalents)

Month	Total	Cle Elum-Roslyn	Ellensburg-Kittitas	Naches-Yakima-Moxee City	Wapato-Toppenish	Sunnyside-Grandview	Prosser-Benton City
January	287	1.0	25.5	59.0	171.0	30.0	1.0
February	283	1.0	25.5	59.0	166.0	30.0	1.0
March	183	1.0	25.5	59.0	66.0	30.0	1.0
April	118	1.0	25.5	54.0	21.0	15.0	1.0
May	93	1.0	26.5	26.0	21.0	17.0	1.0
June	178	1.0	25.5	34.0	66.0	50.0	1.0
July	391	1.0	48.5	154.0	106.0	75.0	7.0
August	461	1.0	48.5	224.0	106.0	75.0	7.0
September	627	1.0	25.5	304.0	156.0	134.0	7.0
October	522	1.0	25.5	264.0	181.0	50.0	1.0
November	298	1.0	26.0	59.0	181.0	30.0	1.0
December	298	1.0	26.0	59.0	181.0	30.0	1.0
AVERAGE	312	1.0	29.5	112.9	118.5	47.2	2.5

1/ Based on inventory in files of USPHS, Portland, Oregon, obtained with cooperation of Washington State Pollution Control Commission.

3. Agricultural

Agricultural wastes are a potential source of BOD and other constituents which often are not conducive to evaluation. It is shown in Chapter VI that cattle, hog, and poultry raising are expected to increase substantially. Over 200,000 cattle, 25,000 hogs, and 330,000 chickens were in the valley in 1959. This represents potential waste production in the study area of about 1,200,000; 50,000; and 50,000 PE, respectively, or a total of 1,300,000 PE. An estimated 5 per cent (or 65,000 PE) of this agricultural waste reaches the waterway. The Washington State Pollution Control Commission is aware of the problem and is, at present, requiring that all feed lots move from stream areas where disposal may be made to land. Dairies, hog sheds, and poultry houses are also required to provide improved disposal techniques.

Return flow from irrigation is a source of quality degradation in the valley that cannot be overlooked. Studies on return flow show that significant BOD concentrations occur in return drains. An average value of 3 mg/l for all return water was selected for flow regulation study purposes. Nutrients are higher in return flows than in the river, and are suspected of promoting excessive nuisance aquatic growths. Pesticides and other agricultural chemicals have been found in return drains. Sufficient data on which to evaluate deleterious effects of pesticides, however, are not available.

C. Water Quality Criteria

The quality of stream waters are described in terms of temperature, turbidity, chemical constituents, bacteriological quality, DO-BOD relationships, and others. The significance of several of these indicators of water quality were discussed in Chapter V.

Fishery agency proposals are for re-establishment of an anadromous fishery and objectives for quality control are aimed toward this use. Spawning areas in the river system are located mainly upstream from the mouth of the Naches River. A minimum DO level of 7 mg/l is required for rearing and spawning and 5 mg/l for fish passage. Flow regulation for control of DO at or greater than 5 mg/l in the lower river, or critical zone where major wastes and return flows are received, would be expected to provide adequate quality for spawning and rearing in upper watershed areas. Control at this level would also provide adequate quality for recreation and for protection of the aesthetic attractiveness of the river. For purposes of this study, therefore, a minimum objective of at least 5 mg/l DO in the lower reaches of the Yakima River has been adopted as the governing criteria.

D. Flow Regulation

Regulation necessary to achieve the above stated quality objectives is based on stream flows required to dilute and assimilate present and projected organic waste loads. TABLE VIII-3 shows the waste loads used in flow regulation computations.

TABLE VIII-3
MAXIMUM MONTHLY WASTE LOADS
(1,000 Population Equivalents)

Area Served	Raw Load			Treated Load (85%)		
	1960	1985	2010	1960	1985	2010
Cle Elum-Roslyn	5.1	7.9	11.4	0.8	1.2	1.7
Ellensburg-Kittitas	37.9	68.3	126.0	5.7	10.2	18.9
Naches-Yakima-Moxee City	411	763	1483	61.6	114.5	222.5
Wapato-Toppenish	187	348	666	28.1	52.2	99.9
Sunnyside-Grandview	167	312	594	25.0	47.1	89.1
Prosser-Benton City	21	31	49	3.2	4.7	7.4
TOTAL (Rounded)	829	1530	2929	124	230	440

The "Federal Water Pollution Control Act, (33 U.S.C. 466b (b))," provides that the inclusion of storage for regulation of stream flow for water quality control shall not be provided as a substitute for adequate treatment or other means of controlling waste at the source. Adequate treatment is considered by the Public Health Service to mean effective waste collection and secondary treatment for domestic wastes and equivalent reduction of industrial waste loads by a combination of process control, internal waste saving, water reuse, and effluent treatment. At the present time, efficiently operated trickling filter plants, widely used in intermediate sized communities, are considered capable of 80 to 90 per cent BOD removal, while the activated sludge process is considered capable of 85 to 95 per cent removal. Considering the effect of diurnal fluctuations in waste loads, problems of efficient operation to maintain such high removals, experience with the lags in plant construction to provide for growth in waste loads,

and urban storm water and/or combined sewer overflows, it is considered reasonable to expect the equivalent of 85 per cent removal of BOD in well operated collection systems and treatment plants at this time.

In this study area, where the largest waste loads are from the food processing industry and where land disposal of waste is practiced, it is believed that a BOD reduction of 85 per cent, with respect to the stream, is feasible for the future and has, therefore, been used for design purposes in this report. Although higher treatment efficiencies may be attainable, allowances must be made for unavoidable contingencies such as the overloading, bypassing, or breakdown of treatment plant facilities.

Problems of efficient operation lags in plant construction, storm water runoff, and other difficulties experienced in the treatment of waste waters must also be recognized. Furthermore, by the end of the 50-year study period, population pressures and land-use may preclude the employment of present-day, high-efficiency industrial waste treatment methods. These considerations dictate a design efficiency of 85 per cent BOD removal.

Stream flows required to maintain the objective under 1960, 1985, and 2010 conditions were computed by means of a technique for balancing the oxygen supply with oxygen consumed in the stream. Computations were made by use of an "oxygen-sag" computer program, which was originally designed for the Willamette River in Oregon.* The

*Worley, John Larry - "A System Analysis Method for Water Quality Management by Flow Augmentation in a Complex River Basin", Master's Thesis, Oregon State University, Published by USDHEW, PHS, Portland, Oregon, June, 1963.

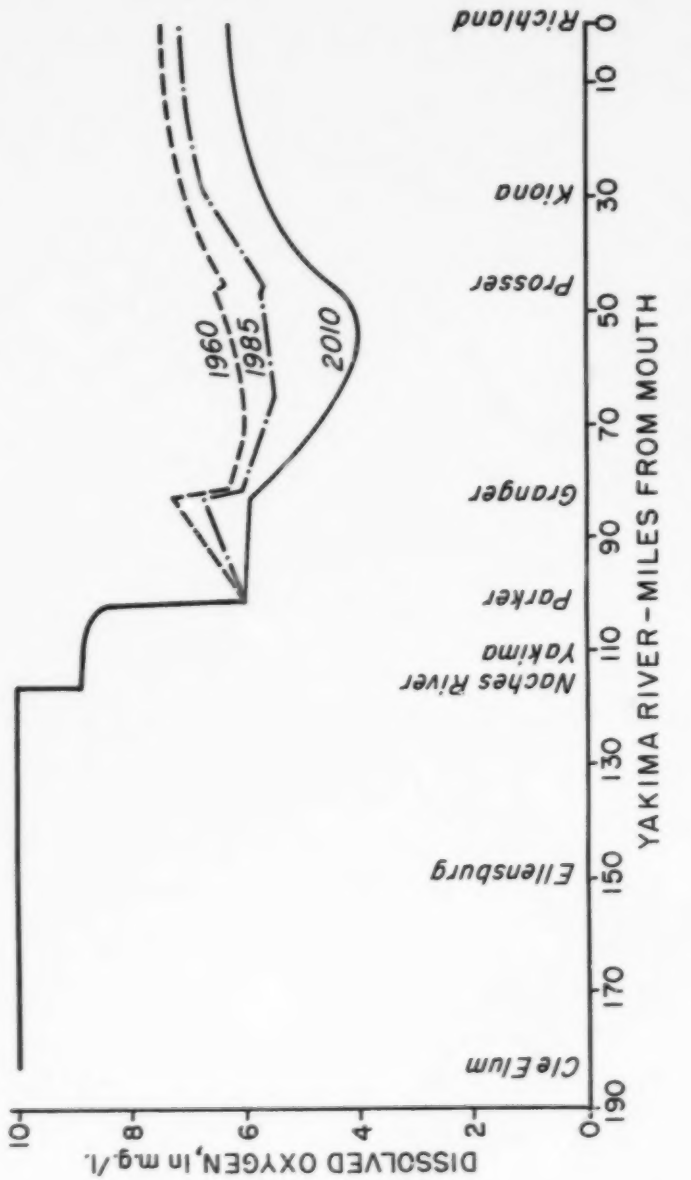
deoxygenation values were established by use of a long-term BOD analyses performed at the Portland U. S. Public Health Service laboratory, and reoxygenation coefficients (k_2) were determined by use of O'Conner's equation for isotropic flows:

$$k_2 = \frac{(D_L\ U)^{1/2}}{2.31\ H^{3/2}}$$

where "D_L" is the diffusion coefficient, "U" is the velocity, and "H" is the stream depth.

The results illustrated in FIGURE VIII-2 show that through the year 1985 sufficient stream flow on a one-in-ten year low-flow recurrence basis is available to assimilate organic waste loadings and still maintain a minimum DO concentration of 5 mg/l in the lower reaches of the river. With loadings expected by the year 2010, however, the objective would not be met. Flows shown in FIGURE VIII-3 were computed only to depict effects at varying levels of loading and quality. By the year 2010, a total average flow of 280 cfs will be required in the lower river to maintain DO at 5 mg/l during the months of July through October.

TABLE VIII-4 outlines an approximate schedule of monthly releases required to maintain quality for fish passage below Sunnyside Diversion Dam on a one-in-ten year low-flow recurrence basis. For design purposes, it was assumed that a base flow of 90 cfs (1-in-10 low flow for Sept.) would be available throughout the critical summer months.



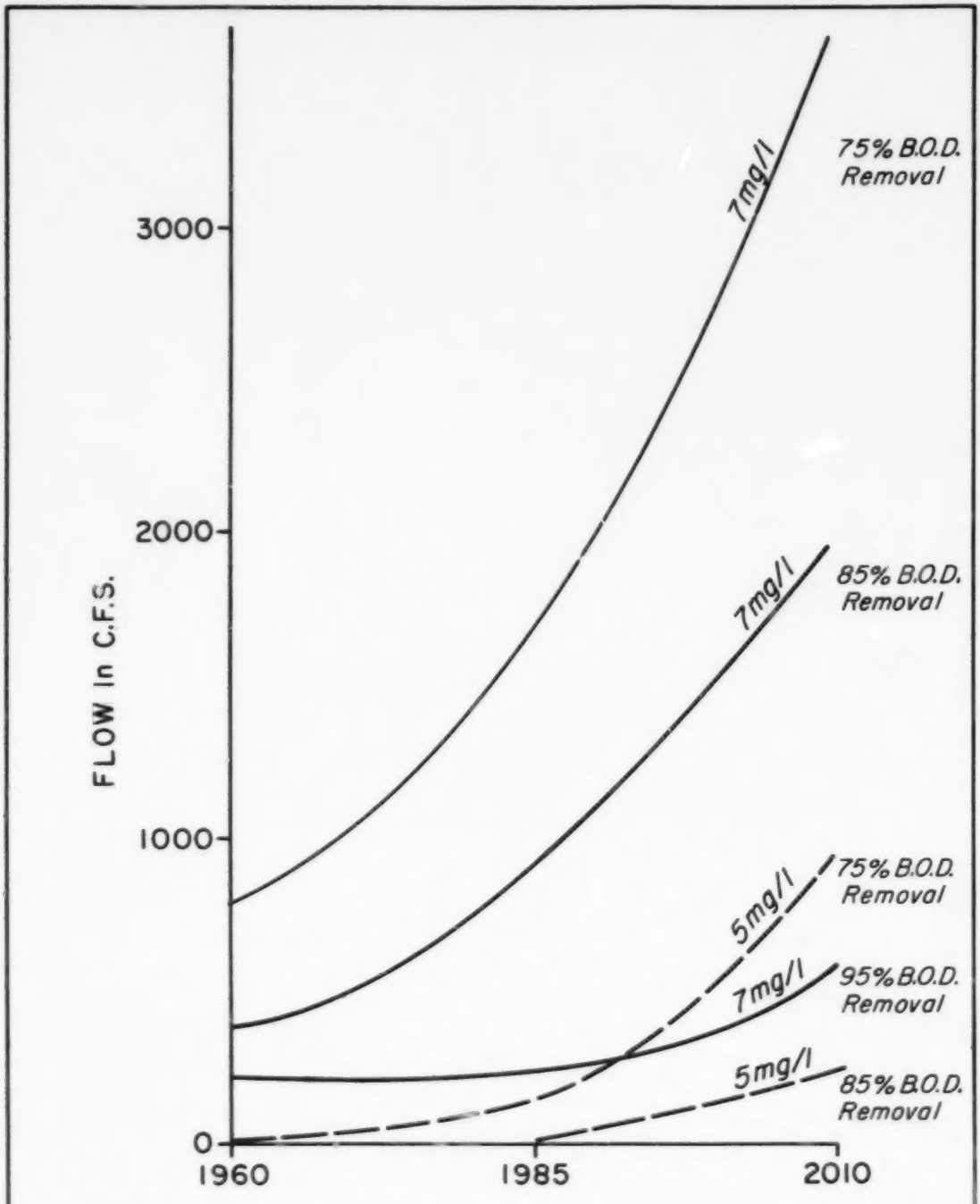
WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

PRESENT & PROJECTED
DISSOLVED OXYGEN PROFILE

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION IX (DATE: 8/65) PORTLAND, OREGON

FIGURE VIII-2



Note:
Flow Required for Minimum Dissolved Oxygen of 5 and 7 mg/1 in Yakima River.

WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

ADDITIONAL FLOW REQUIRED FOR QUALITY CONTROL

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service

REGION IX (DATE: 8/65) PORTLAND, OREGON

FIGURE VIII-3

TABLE VIII-4
REQUIRED STREAM FLOW REGIMEN FOR QUALITY CONTROL PURPOSES[1/]
PARKER TO PROSSER - YEAR 2010
YAKIMA RIVER BASIN, WASHINGTON

	Required Stream Flow cfs	Draft-on-Storage[2/] acre-feet	Estimated Release Schedule cfs	Estimated Release Schedule MGD
January	116	0	0	0
February	116	0	0	0
March	116	0	0	0
April	112	0	0	0
May	85	0	0	0
June	92	0	0	0
July	204	9,200	150	100
August	268	12,100	200	125
September	340	15,300	260	165
October	303	13,400	220	140
November	116	0	0	0
December	116	0	0	0
Annual Average.	165		69	44
Total Annual.		50,000		

1/ Based on adequate treatment of organic wastes discharged to stream.

2/ This is the additional quantity needed downstream from Parker and does not include storage and transmission losses.

As indicated in TABLE VIII-4 there will be a need by the end of the study period for an annual draft-on-storage of about 50,000 acre-feet. This need is expected to begin about the year 1995.

Reservoir releases whould be scheduled to meet the water quality objectives set forth in this report. The estimated release schedule presented in TABLE VIII-4 is provided as an indication of the possible release pattern from the proposed reservoir to meet the total stream flow required below Parker. Because reservoir releases for quality control must vary with waste discharges, stream quality, flow, temperature, reservoir quality, etc., at the time of release, this suggested schedule may require adjustment in the future.

IX. BENEFITS

Benefits can be assigned to releases from storage for regulation of stream flow for water quality control only after a reasonable degree of treatment or control of waste at the source is provided. In this instance, adequate waste control at the source, or 85 per cent BOD reduction with respect to the stream, would not by itself meet the quality goals discussed in Chapter VIII for lower Yakima River. Water quality goals can, however, be met by providing flow regulation in addition to adequate treatment.

Storage releases for control of water quality are needed in the Yakima River to protect fish and wildlife, maintain recreational opportunities, safeguard public health, and preserve the aesthetic attractiveness of stream waters. The precise value of benefits assignable to releases necessary to serve these uses or to prevent damage to these uses, however, is not readily measurable. Many benefits such as those resulting from maintenance of the aquatic habitat, temperature reduction, decreased concentration of suspended and dissolved solids, increased land values along the stream, and general protection of aesthetic values are particularly difficult to completely assess in monetary terms.

Increased commercial and sport fishing is the most notable potential benefit to be derived from water quality control. Estimates have been made of the increased fishing effort that may be realized if fish facilities and stream flows are improved and adequate water

quality is maintained. For example, the annual sports catch of anadromous fish (spring and fall chinook, coho, and steelhead trout) has averaged some 700,000 angler-days, and the annual resident game fish effort in the Yakima River Basin, as a whole, is estimated to be 135,000 angler-days. The value of the potential fishery is estimated to be in excess of 4 million dollars annually.

Recreational opportunities throughout 20 to 30 miles of the river below the Yakima Metropolitan Area would be directly influenced, and a potential population of 300,000 persons would in some way be affected by maintenance of water quality.

Because multiple values would be realized through control of water quality by flow regulation, the composite value of benefits assignable to storage for this purpose is considered at least equal to the cost of the most reasonable alternative means of providing the same level of water quality in the absence of the project.

Since the results achieved by flow regulation relate primarily to control of waste effluents originating from numerous municipal and industrial sources and to the dilution and/or assimilation of residual materials contained in urban and rural land runoff, the only reasonable or known equivalent alternative means of achieving similar results is by releases of water from a single-purpose storage facility. Alternatives such as disposal of waste effluents underground, transportation of wastes downstream, transportation of wastes out of the basin, waste-holding lagoons, or other such means of handling the collectible portion of wastes in the basin would neither be feasible nor would these alternatives produce similar results.

The cost of a single-purpose reservoir constructed at one of the sites currently being considered for potential development in Yakima River Basin was used as a measure of the minimum value of storage in Bumping Lake Reservoir for water quality control. In establishing this value, three sets of cost data were examined. These were:

(1) The average cost of storage construction in the Pacific Northwest;

(2) The cost to enlarge Bumping Lake from 33,700 acre-feet to the required capacity; and

(3) The cost to develop storage on Little Naches River.

Costs in each of the above cases were very similar; however, single-purpose development on the Little Naches River was found to be the least costly.

Based on this alternative, the minimum value of the benefit assignable to an annual draft-on-storage of 50,000 acre-feet in the proposed project with first need beginning in 1995 (assumed project completion in 1975), interest at 3.125 per cent on a 100-year basis, and operation and maintenance expenses of $13,000 annually is estimated to be $150,000 or $3.00 per acre-foot.

In planning for additional water resource development in Yakima River Basin, consideration should be given to preserving the excellent quality of water in upper basin regions and to maintaining sufficient quality in the lower river to permit passage of anadromous fish species to and from spawning areas. Maintenance of water quality for fish

passage would assure continued multiple use of the lower river and its accomplishment would necessitate continued updating of waste treatment facilities, in addition to reserving at least 50,000 acre-feet of storage for future release to the lower river.

Storage for quality control in Bumping Lake Enlargement Project would provide protection of future water quality in the Yakima River and downstream reaches of the Columbia River. The adverse effect of organic wastes remaining even after adequate treatment, as measured in terms of DO demand on the stream, can be reduced to acceptable levels with relatively little additional stream flow. The concentrations of soluble nutrients resulting from irrigation, and from domestic and other wastes, which are not significantly reduced by available treatment methods, can be reduced by dilution.

Controlled water quality will have an important impact on the area for which flow regulation would be provided. The Yakima River flows through many communities and valuable farm lands and is a focal point to travelers passing through the valley. The beauty of the valley, its fisheries, recreation, and other existing potential water-oriented activities are an important asset to the region.

The benefits derived from water quality maintenance in the Yakima River Basin are both tangible and intangible and are widespread both in area and types of beneficiaries.

X. BIBLIOGRAPHY

Chapter I

1. H. T. Nelson, Regional Director, Region I, Letter of Initiation, dated June 20, 1962, Bureau of Reclamation, Boise, Idaho.

Chapters III & IV

2. Gerald A. Waring, Geology and Water Resources of a Portion of South Central Washington, USGS Water Supply Paper 316, 1913.

3. USDI, Bureau of Reclamation, Boise, Idaho, Yakima River Erosion Surveys, 1946.

4. USDI, Bureau of Reclamation, Region I, Boise Idaho, Yakima Project, Washington, Supplemental Storage; May, 1956.

5. Yakima Indian Reservation, Mabton Project, Satus 4 - Satus Flood Control and Irrigation Project; May, 1956.

6. Corps of Engineers, Seattle, Washington, Report on Yakima River and Tributaries, Washington; September, 1956.

7. USDI, Bureau of Reclamation, Region I, Boise, Idaho, Yakima Project, Washington, Kennewick Division Extension, May, 1959 (and revision June, 1962).

8. Bureau of Indian Affairs, Portland Area Office, Toppenish-Simcoe Project, Review Report, Portland, Oregon, July, 1964.

9. USDI, Bureau of Reclamation, Boise, Idaho, Yakima Project, Washington, Prosser Division, 1954.

Chapter V

10. USGS, Surface Water Records of Washington, 1908-1962.

11. H. B. Kinnison, Evaluation of Stream Flow Records in Yakima River Basin, Washington, Geological Survey Circular 180, 1952.

12. H. B. Kinnison and J. E. Sceva, Effects of Hydraulic and Geologic Factors on Stream Flow of the Yakima River Basin, Washington, USGS Water Supply Paper 1595, 1963.

13. W. Van Winkle, Quality of the Surface Waters of Washington, USGS, Water Supply Paper 339, 1914.

14. Columbia Basin Inter-Agency Committee, Inventory of Published and Unpublished Sediment-Load Data and Chemical Analyses of Surface Waters in the Pacific Northwest, 1951; May, 1952.

15. R. O. Sylvester, Water Quality Studies in the Columbia River Basin, Special Scientific Report, Fisheries No. 239, May, 1958.

16. USDHEW, PHS, Region IX, Portland, Oregon, Return Irrigation Water, Characteristics and Effects, May, 1960.

17. Washington Pollution Control Commission, Quality of Surface Waters, June 1959-July 1960, 1961.

18. Frederick W. Poe, M. S. Thesis, Irrigation Return Flows and Water Quality in the Yakima River Basin, University of Washington, Seattle, Washington, 1961.

19. R. O. Sylvester, A Study on the Character and Significance of Irrigation Return Flows in the Yakima River Basin, University of Washington, February, 1962.

20. Washington Pollution Control Commission and Public Health Service, A Study of Aerial Spraying for Spruce Budworm Control on Stream Biota, June, 1962.

21. James P. Behlke, Washington Pollution Control Commission, Preliminary Studies of Water Temperature in the Lower Yakima River, 1956.

22. State College of Washington, Pullman, Washington, Surface and Sub-Surface Waters of the Yakima and Klamath Reclamation Projects, 1928.

23. USGS, Ground Water Levels in the United States, 1956-60, Northwestern States, Water Supply Paper 1760.

Ibid - 1949 WSP 1160
1945 WSP 1027
1943 WSP 990
1942 WSP 948
1940 WSP 910

24. Division of Water Resources, Olympia, Washington, Flowing Artesian Wells in Washington State, Water Supply Bulletin No. 16, 1961.

25. Bruce L. Foxworthy, Geology and Ground Water Resources of the Ahtanum Valley, Yakima County, Washington, Geological Survey Water Supply Paper 1598, 1962.

26. G. L. McGuiness, Role of Ground Water in National Water Situation, Water Supply Paper No. 1800, USGS, 1963.

27. M. J. Mundorff, Availability of Ground Water to Supplement Surface Water Irrigation Supplies in the Yakima River Basin, Open File Report USGS, Water Resources Division, Tacoma, Washington.

28. L. V. Wilcox and Carl E. Nelson, The Ground Water and Salt Balance Conditions of the Sunnyside Valley Irrigation District for the Period March 1 to October 31, 1944, USDA, Rubidoux Laboratory, Riverside, California, 1945.

29. USGS Water Resources Division, Tacoma, Washington, Ground Water in Washington: Its Chemical and Physical Quality, (In press by State of Washington).

Chapter VI and VII

30. Pacific Power and Light Company, Industrial Sites, Yakima County, Washington, August, 1962.

31. Washington Crop and Livestock Reporting Service, 348 Federal Office Building, Seattle, Washington 98104, Yakima County Agriculture, Washington, County Agricultural Data Series, 1964.

32. O. W. Lindgren, Water Supply Study, Rattlesnake Watershed, (Report prepared for City of Yakima), 1960.

33. City of Ellensburg, Annual Report, 1961.

34. City of Sunnyside, Fourteenth Annual Report, 1961.

35. Gray and Osborne, Consulting Engineers, Yakima, Washington, An Engineering Report on Water Facilities for the City of Yakima,Washington, September, 1963.

Chapter VIII

36. Fish and Wildlife Service, Portland, Oregon, Preliminary Evaluation Report on Fish and Wildlife Resources, Roza Division, Yakima Irrigation Project, Yakima River, Washington, Sept.,1951.

37. Washington State Department of Fisheries, Yakima Rehabilitation Program, January, 1956 (Revised December, 1962).

38. Washington State Department of Health, First Report Stream Pollution Studies, Yakima River Valley, 1936.

39. Washington Pollution Control Commission, An Investigation of Pollution in the Yakima River Basin, Technical Bulletin No. 9, Summer 1951.

40. Washington Pollution Control Commission, A Comprehensive Pollution Control Program for the Yakima River Basin, Basin No. 25, 1952.

41. Cornell, Howland, Hayes, & Merryfield, An Engineering Study of Waste Treatment and Infiltration for the City of Yakima, Washington, February, 1963.

42. Cornell, Howland, Hayes, & Merryfield, An Investigation of Industrial Waste Treatment Facilities for the Prosser Industrial Tract, Port of Benton Commission, Benton County, Washington, 1964.

APPENDIX A

WATER QUANTITY DATA

APPENDIX A

TABLE 1
FLOW DATA FOR THE YAKIMA RIVER NEAR PARKER, 1941-62
(cfs)

	Water Year	Annual Mean	Minimum Month		Minimum 7 Days		Minimum Day	
1	1962	1,499	277	Sept.	99.8	Oct. 5-11	14.5	Oct. 7
2	1961	2,790	274	Sept.	80.7	Sep. 7-13	53	Sep. 10
3	1960	2,870	297	Aug.	166.7	Sep. 8-14	74	Sep. 12
4	1959	2,912	275	July	110.9	Oct. 2-8	38	Oct. 3
5	1958	1,655	247	Sept.	163.3	July 9-15	49	July 10
6	1957	2,555	283	Sept.	160.3	Aug. 14-20	53	Aug. 16
7	1956	5,118	278	Sept.	130.4	Sep. 16-22	92	Sep. 17
8	1955	1,851	410	Sept.	255.7	Sep. 21-27	204	Apr. 29
9	1954	2,775	718	Aug.	145.6	Sep. 3-9	71	Sep. 5
10	1953	1,574	224	Sept.	128.9	Oct. 5-11	54	Oct. 6
11	1952	1,324	207	Sept.	74.9	May 2-8	38	May 3
12	1951	4,159	191	Sept.	97.1	Sep. 14-20	52	Sep. 19
13	1950	3,607	652	Aug.	652.1	July 30-Aug.5	265	July 15
14	1949	2,971	360	July	185.1	Oct. 12-18	58	Oct. 17
15	1948	3,263	304	Aug.	182.9	Aug. 9-15	72	Aug. 13
16	1947	2,386	190	Aug.	183.4	Aug. 10-16	61	Aug. 15
17	1946	2,216	197	Aug.	- - -		- - -	
18	1945	955	178	July	88.0	Oct. 10-16	63	Oct. 16
19	1944	655	157	Aug.	166.4	Sep. 18-24	44	Apr. 18 & Sep. 19
20	1943	2,466	178	Sept.	95.9	Oct. 14-20	34	Oct. 18
21	1942	903	179	Sept.	61.7	Apr. 26-May 2	33	Apr. 29
22	1941	744	107	July	41.6	Apr. 17-23	20	Apr. 18
	MEAN	2,329	281		153		70	
	MEDIAN	2,426	260		129		54	

Data Source: U. S. Geological Survey

Drainage Area: 3,650 square miles.
Average Discharge: 2,329 cfs = 1,687,000 acre-feet per year.
Period of Record: 1908-1963.
Maximum Day: 65,000 cfs
Minimum Day: Less than 10 cfs (most years prior to 1936).

TABLE 2
FLOW DATA FOR THE YAKIMA RIVER AT KIONA, 1941-62
(cfs)

	Water Year	Annual Mean	Minimum Month		Minimum 7 Days		Minimum Day	
1	1962	2,752	1,375	July	1,190	July 13-19	1,030	July 14
2	1961	4,217	1,216	July	1,004	July 18-24	860	July 22
3	1960	4,020	1,224	July	1,111	July 18-24	959	July 23
4	1959	4,307	1,415	July	1,160	July 15-21	1,050	July 17
5	1958	2,957	1,225	July	1,050	July 12-18	914	July 14
6	1957	3,864	1,418	July	1,286	June 20-26	1,060	June 21
7	1956	7,055	2,235	Sept.	1,793	Aug. 12-18	1,760	Aug. 16
8	1955	3,068	1,809	Aug.	1,483	Apr. 16-22	1,180	Apr. 20
9	1954	4,269	2,162	Nov.	1,763	Oct. 10-16	1,650	Oct. 16
10	1953	3,030	1,678	Dec.	1,330	Apr. 12-18	1,240	Apr. 17
11	1952	2,775	1,899	Aug.	1,650	July 14-20	1,390	July 17
12	1951	5,801	1,722	Aug.	1,621	July 14-20	1,550	July 19
13	1950	4,993	1,911	Aug.	1,560	Jan. 13-19	1,550	Jan. 14-18
14	1949	4,313	1,785	July	900	Feb. 4-14(Ice)	900	Feb. 4
15	1948	4,820	1,866	Sept.	1,669	Aug. 10-16	1,550	Aug. 15
16	1947	3,762	1,520	Aug.	1,377	Aug. 11-17	1,360	July 11
17	1946	3,442	1,541	Aug.	- - -		- - -	
18	1945	2,021	1,389	July	1,220	July 4-14	1,180	July 8
19	1944	1,642	1,394	July	791	Apr. 17-23	730	Apr. 20
20	1943	3,796	1,487	Sept.	1,389	Sep. 9-15	1,360	Sep. 9
21	1942	2,013	1,435	Aug.	1,141	Apr. 28-May 4	1,060	Apr. 30 & May 1
22	1941	1,843	1,318	Aug.	857	Apr. 25-May 1	840	Apr. 26-27
MEAN		3,671	1,637		1,302		1,194	
MEDIAN		3,779	1,503		1,286		1,180	

DATA SOURCE: U. S. Geological Survey

Drainage Area-- - 5,600 square miles (approximately).
Average Discharge - 3,671 cfs = 2,660,000 acre-feet per year.
Period of Record - 1896-1915 and 1933-1963
Maximum Day - 67,000 cfs
Minimum Day - 105 cfs (Sept.,1906).

TABLE 3
MEAN MONTHLY LOW FLOWS WITH
ONCE-IN-TWO YEAR RECURRENCE FREQUENCY
(cfs)

Month	Parker	Kiona
January	2,130	3,030
February	2,220	3,440
March	2,560	3,600
April	2,940	4,500
May	4,730	5,900
June	4,100	5,700
July	365	1,670
August	335	1,630
September	270	1,870
October	950	2,360
November	1,740	2,650
December	2,250	3,150
Mean	2,050	3,290

TABLE 4
MEAN MONTHLY LOW FLOWS WITH
ONCE-IN-FIVE YEAR RECURRENCE FREQUENCY
(cfs)

Month	Parker	Kiona
January	1,060	2,000
February	1,070	2,250
March	1,330	2,440
April	1,500	3,000
May	2,430	3,950
June	2,100	3,800
July	187	1,100
August	173	1,050
September	140	1,250
October	485	1,570
November	900	1,760
December	1,170	2,120
Mean	1,045	2,190

TABLE 5
MEAN MONTHLY LOW FLOWS WITH
ONCE-IN-TEN YEAR RECURRENCE FREQUENCY
(cfs)

Month	Cle Elum	Umtanum	Union Gap[1/]	Parker	Granger[1/]	Kiona
January	506	896	2,000	680	922	1,550
February	440	768	2,190	725	1,024	1,790
March	429	1,168	1,910	840	1,126	1,860
April	1,111	2,208	3,850	953	1,336	2,320
May	2,068	3,200	6,170	1,550	1,968	3,040
June	2,156	2,896	5,300	1,340	1,795	2,960
July	1,892	2,064	3,270	120	327	855
August	1,892	2,224	3,030	110	313	830
September	1,342	1,584	2,390	90	332	960
October	484	800	1,450	316	571	1,220
November	341	608	1,370	575	799	1,370
December	550	784	1,280	740	990	1,630
Mean	1,100	1,600	3,000	680	--	1,700

1/ Data computed from other stations.

APPENDIX B

WATER QUALITY DATA

APPENDIX B

TABLE 1
SURFACE WATER QUALITY
YAKIMA RIVER BASIN, WASHINGTON

Location & Date	Time	Temperature (°C)	Dissolved Oxygen (mg/1)	5-Day BOD (mg/1)
Yakima River @ Selah:				
9/20/61	0925	14.5	9.3	0.8
2/28/62	1215	0.5	13.8	0.9
8/14/62	0325	15.2	8.1	1.5
8/14/62	0947	16.5	9.7	4.6
8/14/62	2135	17.4	9.3	3.1
9/25/62	0015	15.9	8.9	1.5
9/25/62	0415	13.5	8.7	0.9
9/25/62	0805	14.5	9.2	1.2
9/25/62	1200	17.7	10.4	1.5
9/25/62	1600	22.7	8.2	3.0
9/25/62	2000	19.2	8.4	5.7
Yakima River @ Granger:				
9/20/61	1125	18.1	9.6	2.6
8/15/62	0445	17.5	6.0	1.8
8/15/62	1035	19.7	8.6	1.5
8/15/62	1645	22.5	10.5	2.5
8/15/62	2235	20.5	7.4	1.8
8/16/62	0045	19.0	6.5	2.2
8/16/62	0725	18.1	8.4	5.0
8/16/62	1445	21.0	9.8	7.2
8/16/62	1855	22.3	9.6	1.4
9/26/62	0045	16.8	7.0	1.0
9/26/62	0455	15.3	6.2	1.2
9/26/62	0850	15.6	7.0	0.9
9/26/62	1235	20.0	10.4	3.5
9/26/62	1650	19.8	11.4	2.2
9/26/62	2030	19.1	8.6	3.4
Yakima River @ Prosser:				
9/21/61	1000	16.0	9.2	1.2
8/15/62	0550	21.2	9.1	1.6
8/15/62	1125	22.2	8.8	1.9
8/15/62	1620	22.8	9.0	1.9
8/15/62	2130	21.7	9.3	3.4
9/26/62	0255	17.3	9.7	1.3

SOURCE: Joint survey by USPHS and Washington Pollution Control Commission.

APPENDIX B

TABLE 2

YAKIMA RIVER, September 18-19, 1962

Location	Total Coliforms	Fecal Coliforms	Fecal Streptococci
Roza	6,900	760	530
Selah Gap	3,300	520	92
Naches	3,500	340	188
Union Gap	40,000	4,300	17,000
Granger	30,000	3,800	126
Marion Drain	5,200	1,600	460
Mabton	6,700	3,100	960
Sunnyside Canal	6,900	1,800	23[illegible]
Prosser	1,900	290	[illegible]
Kiona	5,700	350	52

YAKIMA RIVER, September 25-26, 1962

Roza	1,900	220	470
Selah Gap	1,800	1,100	250
Selah Drain	20	<10	28
Naches	2,100	310	100
Union Gap	10,500	4,800	7,700
Granger	60,000	---	190
Granger Drain	30,000	---	2,900
Marion Drain	2,800	---	690
Mabton	25,000	---	460
Sunnyside Canal	2,600	450	68
Prosser	6,500	---	28
Kiona	13,000	---	72
Moxee Drain	40,000	3,400	1,800
Ahtanum Creek	5,700	260	360
Wide Hollow Creek	120,000	44,000	6,300
Sulfur Creek	120,000	---	5,800
Satus Creek	30,000	---	580
Toppenish Creek	1,200	---	280
McDonald Drain	40,000	---	1,900
East Toppenish Drain	50,000	---	580

APPENDIX B

TABLE 3
YAKIMA RIVER PLANKTON, NUMBERS PER LITER
September 25-26, 1962

Organisms (Common)	Yakima R. @ Selah Gap	Yakima R. @ Union Gap	Naches R. @ Mouth #2	Yakima R. @ Kiona #4	Yakima R. @ Mabton #5	Yakima R. @ Granger #6
Diatoms						
Navicula	270,000	199,000	140,000	157,000	390,000	560,000
Synedra	130,000	100,000	102,000	177,000	320,000	640,000
Diatoma	62,000	72,000	32,000	55,000	48,000	160,000
Cymbella	14,000	26,000	50,000	1,600	20,000	25,000
Cocconeis	32,000	48,000	28,000	95,000	34,000	130,000
Cyclotella	10,000	20,000	6,400	61,000	32,000	17,000
Gomphonema	40,000	18,000	15,000	4,700	16,000	28,000
Melosira	6,000	24,000	26,000	1,600	12,000	12,000
Achnanthes	8,500	38,000	7,200	---	12,000	17,000
Amphora	5,000	18,000	48,000	4,700	3,000	8,500
Rhoicosphenia	10,000	8,000	7,700	55,000	18,000	7,200
Meridion	2,500	1,700	17,000	---	2,100	7,700
Fragilaria	3,400	1,300	5,100	1,600	5,000	5,500
Other Diatoms	66,000	5,500	50,000	---	4,800	3,400
Blue-Green Algae						
Oscillatoria	5,100	1,700	429	12,000	10,000	3,400
Anabaena	1,300	429	429	1,600	2,500	1,300
Green Algae						
Scenedesmus	858	---	858	51,000	19,000	20,000
Other Greens	52,000	11,000	3,000	3,100	15,000	31,000
Desmids						
Desmidium	---	1,300	2,500	6,300	---	8,100
Other Desmids	66	11	---	---	---	1,300
Protozoa						
All Protozoa	33	2,100	1,700	---	3,000	44
Slimes						
Sphaerotilus & Assoc. Slimes.	22	34,000	---	2,700	---	---
Flagellates						
Dinobryon	7,700	429	---	---	---	---
Other Flagellates	439	---	---	---	---	---
TOTALS	726,908	630,469	543,316	690,900	966,400	1,686,444

APPENDIX B

TABLE 4a

STATION NO. 1

Donald-Wapato Bridge
Water and Air Temperatures in Degrees of Fahrenheit

	August						September					
1955	Water Temp.			Air Temp.			Water Temp.			Air Temp.		
Date	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
1	65	57	61	84	61	73	56	48	52	88*	53	71
2	62	56	59	79	60	70	57	50	53	89	55	72
3	61	53	57	80	56	68	58	51	54	92	62	77
4	62	53	57	86	54	69	58	51	54	91	58	75
5	64	55	59	90	55	72	57	50	53	91	56	73
6	64	56	60	95	57	76	57	50	53	91	58	74
7	64	56	60	92	62	77	55	51	53	87	71	79
8	62	55	58	85*	55	70	54	49	51	76	63	70
9	62	53	57	85	55	70	55	48	52	82	53	67
10	63	53	58	90	55	72	56	48	52	84	53	68
11	62	55	58	87*	69	78	55	47	51	82	59	71
12	62	53	58	81	62	71	53	46	49	78*	47*	63
13	58	51	54	81	55	68	48	47	48	65	50*	57
14	59	51	55	84*	55	70	47	45	46	65	50	57
15	59	51	55	87*	61	74	47	43	45	64	46	50
16	59	52	55	85*	62	74	48	43	46	67	46	56
17	60	52	55	86	59	68	48	42	45	70	46	58
18	60	52	56	87*	59	74	49	43	45	76	51	64
19	61	53	56	88	68	78	50	44	47	80	46	63
20	60	53	56	82	60	71	50	45	47	67	47	57
21	58	50	54	81*	51	68	46	42	44	64	47	56
22	59	51	55	83*	60	72	45	40	43	65	37	51
23	58	50	54	81	59	70	48	41	44	72	46	59
24	57	49	52	80	57	69	48	43	45	71	43	57
25	56	48	52	77	53	65	47	41	44	73	40	56
26	56	48	53	78	55	67	46	41	43	70	38	54
27	57	48	52	83	53	68	44	43	44	58	55	56
28	57	49	53	81	60	71	45	41	43	64	45	60
29	57	49	53	88	53	70	45	39	42	68	39	53
30	57	50	53	89	59	74	45	39	42	69	41	55
31	57	49	53	86	54	70						

*Estimate

APPENDIX B

TABLE 4b

STATION NO. 2

Chandler

Water and Air Temperatures in Degrees of Fahrenheit

1955	August						September					
	Water Temp.			Air Temp.			Water Temp.			Air. Temp.		
Date	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
1	74	67	70	88	60	74	73	63	68	96	46	71
2	74	66	70	86	48	67	72	64	68	97	48	73
3	73	65	69	84	45	63	72	65	68	94	54	74
4	73	64	69	87	46	67	72	65	68	92	68	80
5	75	64	69	96	50	73	72	65	69	94	52	73
6	76	66	71	99	52	76	71	56	68	96	57	76
7	75	67	71	97	57	77	71	65	68	92	59	76
8	75	67	71	87	53	70	67	64	66	80	58	69
9	75	66	71	88	48	68	69	62	66	89	53	71
10	76	66	71	95	50	73	69	62	66	89	51	70
11	77	67	72	95	54	75	69	62	65	87	54	71
12	74	66	70		48	66	68	61	65		44	69
13	73	64	68	85	46	66	64	61	63	75	46	60
14	74	64	69	90	46	68	61	60	60	68	54	61
15	74	65	69	90	49	70	60	56	58	68	43	55
16	74	65	69	89	51	70	62	37	59	72	50	61
17	74	65	70	92	50	71	62	56	59	72	38	54
18	76	66	71	98	53	75	62	57	59	74	41	57
19	75	67	71	94	56	75	63	57	60	83	43	57
20	74	66	70	89	53	71	63	59	61	74	52	63
21	74	64	69	86	51	69	60	57	59	66	43	54
22	74	65	69	92	53	72	60	55	58	66	33	49
23	73	65	69	98	53	75	61	56	58	70	43	57
24	72	64	68	85	52	68	60	55	57	70	36	53
25	70	63	66	80	47	63	61	54	57	73	34	53
26	71	62	66	84	43	63	60	54	57	79	44	61
27	71	62	66	85	43	64	58	57	57	62	54	59
28	71	63	67	84	43	64	70	55	57	68	43	55
29	71	62	67		47	68	59	54	57		35	51
30	73	63	68	89	46	67	60	54	57	70	36	53
31	72	74	68	94	45	69						

TABLE 4c

STATION NO. 3

Richland
Water and Air Temperatures in Degrees of Fahrenheit

	August						September					
1955	Water Temp.			Air Temp.			Water Temp.			Air Temp.		
Date	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
1	75	69	72	95	67	81	74	66	70	98	53	76
2	74	68	71	91	54	73	74	68	71	99	55	77
3	74	66	70	87	52	70	75	69	72	101	61	81
4	75	67	71	88	54	71	73	68	71	101	65	83
5	76	68	72	94	56	75	74	68	71	99	60	80
6	78	69	74	100	61	81	72	69	71	101	62	82
7	77	70	74	104	64	84	72	68	70	101	64	83
8	77	69	73	100	59	80	70	65	68	96	60	78
9	76	69	73	91	57	74	71	66	69	84	55	70
10	77	69	73	94	60	77	70	66	68	91	54	73
11	77	70	74	100	62	81	69	64	67	95	56	76
12	77	70	74	101	55	78	66	65	66	90	48	69
13	75	68	72	90	57	74	65	61	63	83	50	67
14	74	68	71	90	54	72	60	58	59		56	67
15	74	69	72		57	76	63	59	61	78	50	64
16	74	68	71	95	58	77	63	59	61	69	51	60
17	75	67	71	92	56	74	64	59	62	73	44	39
18	76	69	73	96	60	78	64	60	62	74	48	61
19	76	70	73	99	67	83	64	60	62	79	46	63
20	76	70	73	95	59	77	63	61	63	85	56	71
21	75	68	72	88	55	72	61	57	59	75	48	62
22	74	68	71	92	56	74	62	58	60	71	37	54
23	73	67	70	94	55	75	61	58	60	73	48	61
24	73	67	70	91	54	73	62	57	60	76	40	58
25	72	65	69	87	55	71	61	57	59	75	40	58
26	71	65	68	81	49	65	60	59	60	76	45	61
27	72	66	69	89	51	70	60	58	59	81	57	69
28	71	66	69	92	61	77	60	57	59	68	48	58
29	72	66	69	89	54	73	61	57	59	68	42	55
30	73	66	70	98	57	78				69	40	55
31	73	67	70	102	57	80						

TABLE 5
WAPATO IRRIGATION PROJECT DRAIN WATER QUALITY

Drain	Average Characteristics for Irrigation Season						
	pH	BOD	COD	Hardness (as $CaCO_3$)	Turbidity	Susp. Solids	Dissolved Solids
E. Toppenish	6.8	2.1	8.7	105	10	24	187
McDonald	7.1	1.8	7.6	110	5	27	195
Marion	7.4	1.4	7.2	116	5	18	219
Toppenish Creek	7.4	1.3	8.6	123	6	18	231
Satus Creek	7.4	1.2	8.1	112	6	40	225
South	7.3	1.1	8.6	123	13	55	241
Coulee	7.4	1.8	10.9	182	12	60	363
Satus 302	7.8	2.0	14.8	94	62	477	226
Satus 303	7.9	1.8	9.1	101	27	136	182

WAPATO IRRIGATION PROJECT, PRINCIPAL NON-CARBONATE IONS

Item	Average Characteristics for Irrigation Season					
	NH_3+	NO_3-	PO_4-	Cl-	SO_4-	Na+
Intake						
Main Canal	0.05	0.09	0.10	1.9	3.5	6.0
Toppenish Creek	0.04	0.06	0.17	0.8	0.8	6.0
Satus Creek	0.04	0.44 1/	0.21 2/	1.2	1.0	6.3
Drain						
E. Toppenish	0.38	1.46	0.66	4.2	6.8	11.7
McDonald	0.06	1.16	0.18	5.7 3/	8.0	13.0
Marion	0.06	0.82	0.24	4.2 3/	10.3	19.3
Toppenish Creek	0.06	0.36	0.24	5.5 3/	11.9	23.5
Satus Creek	0.04	0.45	0.23	5.0 3/	10.8	19.7
South	0.07	0.83	0.30	4.5	12.2	22.5
Coulee	0.08	0.72	0.47	7.5 3/	53.8 4/	50.5 5/
Satus 302	0.11	0.49	0.32	3.0	7.5	13.8
Satus 303	0.07	1.15	0.24	4.5	17.1	16.4

Units of measurement are milligrams per liter.

1/ Average would have been 0.02 except for high readings of 2.00 and 3.06 for which there is no explanation.

2/ Average would have been 0.09 except for one high reading of 1.53 for which there is no explanation.

3/ Includes at least one high value between 10.0 and 26.0.

4/ Includes three readings over 110.0 late in the season.

5/ Includes three readings between 80.0 and 100.0.

APPENDIX B

TABLE 6
GROUND WATER QUALITY

Location	Well Depth (ft)	Temp °F	Color	pH	N.C. Hard	Total Hard	Dis. Solids	SiO_2	Fe	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	F	NO_3	PO_4
							YAKIMA COUNTY													
Near Sunnyside	99	61	5	7.9	24	179	315	57	.01	48	14.0	17.0	7.4	0	190	44.0	11.0	0.4	2.3	.07
Near Toppenish	160	--	--	--	--	87	136	32	.05	22	7.9	6.8	1.9	0	113	5.1	2.7	0.0	2.0	--
	863	69	0	7.8	0	42	158	68	.08	13	2.2	19.0	4.1	0	105	0.3	1.0	0.6	0.2	--
Upper Ahtanum Valley	146	---	5	7.7	0	80	155	54	.02	16	9.7	10.0	1.8	0	116	4.4	3.0	0.2	1.6	--
	11	--	10	7.3	0	49	111	47	.11	10	5.8	5.6	3.7	0	74	24.0	0.7	0.2	1.0	--
	384	60	0	7.9	0	54	149	53	.05	13	5.3	17.0	3.2	0	113	0.4	1.8	0.5	0.1	--
	1078	63	8	7.9	0	57	114	38	.24	12	6.6	7.2	3.1	0	85	4.4	1.2	0.3	0.2	--
Lower Ahtanum Valley	18	--	25	7.2	0	117	205	51	.02	24	14.0	16.0	5.6	0	180	5.1	2.5	0.3	1.8	--
	30	--	25	7.2	0	107	209	52	.03	23	12.0	19.0	5.3	0	160	8.0	11.0	0.2	1.5	--
	213	--	5	7.3	32	141	251	61	.03	30	16.0	9.6	3.2	0	133	29.0	18.0	0.3	2.7	--
In Yakima	85	--	15	7.3	35	130	221	39	.02	34	11.0	12.0	4.8	0	116	21.0	26.0	0.3	6.0	--
Wenas Valley	Spring	59	--	7.6	0	158	262	66	.02	32	19.0	13.0	5.8	0	193	18.0	9.1	0.2	3.1	--
	127	--	--	8.3	11	183	309	58	.02	42	19.0	23.0	2.9	0	210	21.0	20.0	0.4	1.6	--
	60	--	--	7.7	0	256	445	53	.03	60	26.0	62.0	4.8	0	442	20.0	5.2	0.4	6.2	--
	385	55	--	7.2	0	90	167	42	.13	12	7.2	23.0	5.0	0	124	9.8	2.0	0.4	0.1	--
	400	--	--	7.5	0	107	205	59	.03	23	12.0	13.0	4.0	0	146	10.0	5.2	0.2	2.1	--
	115	--	--	7.4	0	78	162	61	.07	15	9.2	8.8	4.8	0	116	3.3	2.4	0.2	0.7	--
	Spring	62	--	7.7	0	57	156	53	.06	12	6.6	17.0	4.3	0	104	9.2	1.8	0.4	0.3	--
Selah	131	54	5	7.9	0	338	559	57	.00	84	31.0	58.0	6.3	0	459	60.0	13.0	0.6	7.0	--

Continued, next page

APPENDIX B

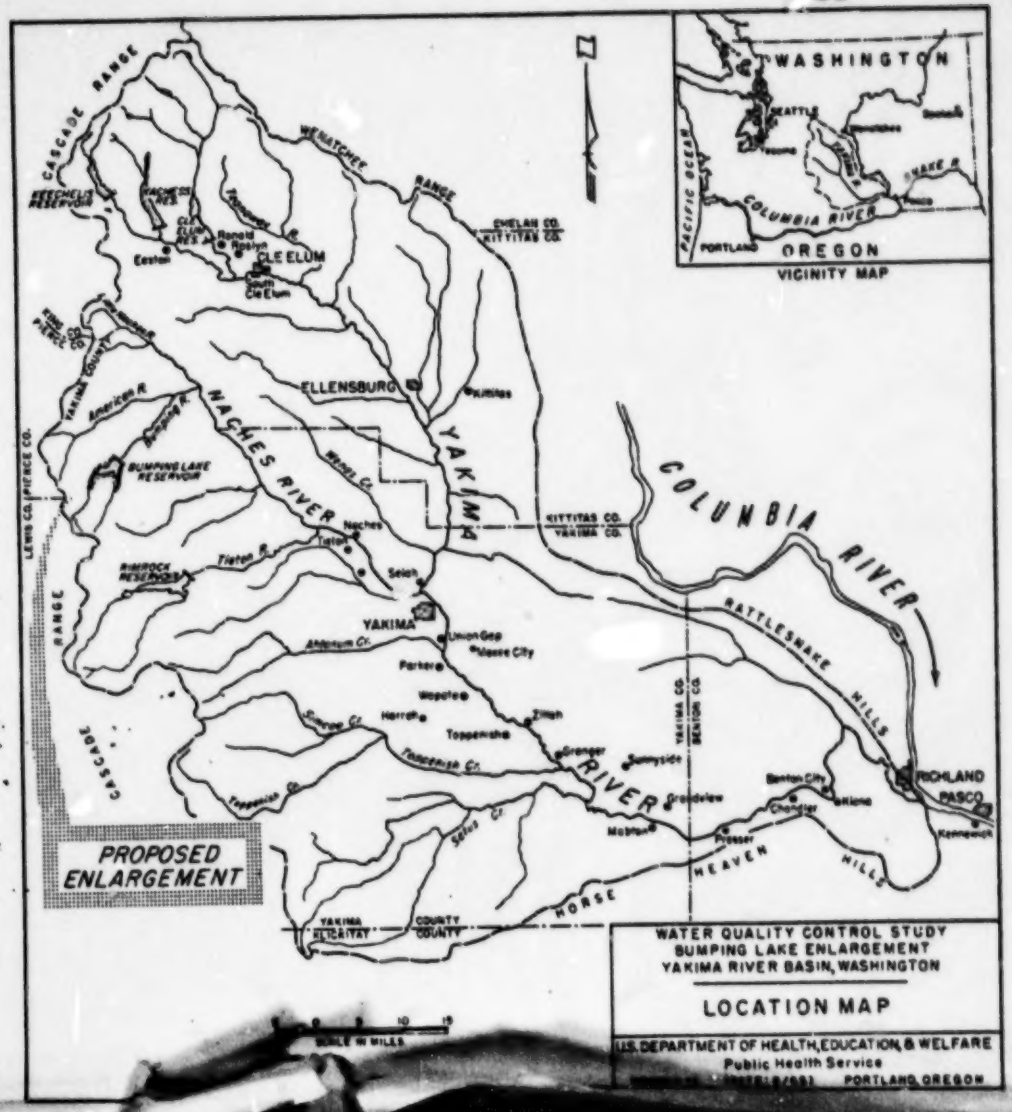
TABLE 6 (continued)

GROUND WATER QUALITY

Location	Well Depth (ft)	Temp °F	Color	pH	N.C. Hard	Total Hard	Dis. Solids	SiO_2	Fe	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	F	NO_3	PO_4
Yakima	550	62	5	7.6	0	152	272	49	.03	33	17.0	30.0	4.9	0	225	19.0	8.4	0.6	4.6	--
Firing Center*	550	68	0	7.8	0	83	174	49	.04	16	11.0	18.0	3.7	0	147	0.6	3.9	0.5	0.2	--
						Benton County														
Prosser	502	66	0	7.7	0	56	229	59	.05	14	5.1	43.0	12	0	187	4.8	6.5	0.6	0.2	.11
	599	63	0	7.5	0	68	248	50	.12	17	6.1	54.0	9.8	0	221	0.1	11.0	0.9	0.2	.08
	740	60	5	7.8	0	67	236	46	.06	16	6.6	46.0	10	0	202	0.6	9.5	0.7	0.1	.09
North of Benton City	420	--	5	7.7	38	182	262	51	.68	38	.21	13.0	4.8	0	176	4.3	7.5	0.2	4.5	--
North of Richland	228	--	5	9.2	0	39	130	18	.05	9.2	3.8	25.0	4.8	16	58	2.1	10.0	1.0	0.3	--
						Kittitas County														
Ellensburg	1209	55	0	7.4	0	83	151	58	.02	18	9.2	8.6	2.0	0	120	1.3	2.0	0.2	0.8	.25

*Averages of several wells.

SOURCE: U. S. Geological Survey


WASHINGTON
SEATTLE
PACIFIC OCEAN
COLUMBIA RIVER
PORTLAND
OREGON
VICINITY MAP
CASCADE RANGE
WENATCHEE
RANGE
CHELAN CO.
KITTITAS CO.
CLE ELUM
Ronald
Easton
South Cle Elum
KING CO.
PIERCE CO.
YAKIMA COUNTY
ELLENSBURG
Thorp
American R.
Naches R.
NACHES RIVER
YAKIMA
Wilson Cr.
BUMPING LAKE RESERVOIR
LEWIS CO.
PIERCE CO.
KITTITAS CO.
YAKIMA CO.
COLUMBIA RIVER
Naches
Tieton
Tieton R.
Selah
RIMROCK RESERVOIR
YAKIMA
Union Gap
Moxee City
Ahtanum Cr.
Porter
Wapato
Harrah
Toppenish
Zillah
Satus Cr.
Toppenish Cr.
Granger
Sunnyside
YAKIMA CO.
BENTON CO.
RATTLESNAKE HILLS
RICHLAND
PASCO
Benton City
Grandview
Prosser
Mabton
Kennewick
HEAVEN
HILLS
HORSE
CASCADE RANGE
PROPOSED ENLARGEMENT
YAKIMA INDIAN RESERVATION
COUNTY
COUNTY
0 5 10 15
SCALE IN MILES
WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON
LOCATION MAP
U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
Public Health Service
PORTLAND, OREGON

WATER QUALITY CONTROL STUDY
BUMPING LAKE ENLARGEMENT
YAKIMA RIVER BASIN, WASHINGTON

LOCATION MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Public Health Service
REGION IX (DATE: 8/65) PORTLAND, OREGON